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JUNE 1987

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A MEMO FROM THE PUBLISHER

Arthur Fisher of Popular Science wins prestigious science journalism award!

New York—Arthur Fisher, *Popular Science's* science & technology editor, has won the 1986 American Association for the Advancement of Science (AAAS) Westinghouse Science Journalism Award for magazines.



The award, along with a cash prize, is given each year in recognition of outstanding reporting on the natural sciences and their engineering and technological applications.

The AAAS is the largest and oldest general science organization in the United States. Fisher is the second *Popular Science* writer to win this prestigious award. C.P. Gilmore, editor-in-chief, won the prize in 1980.

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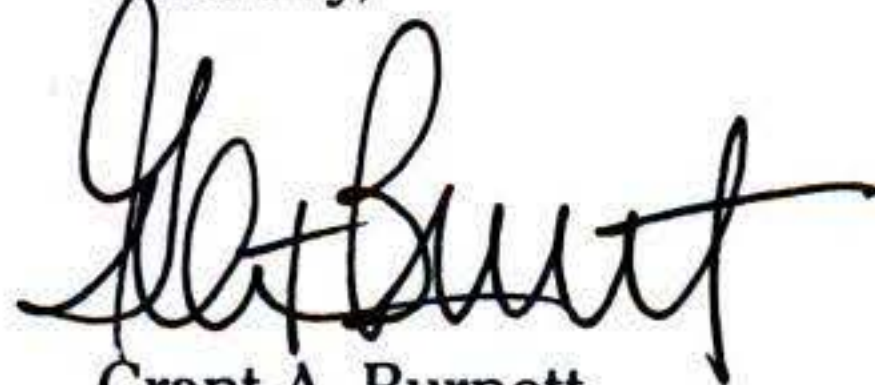
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Grant A. Burnett
Publisher

This One



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**Popular
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The WHAT'S NEW magazine

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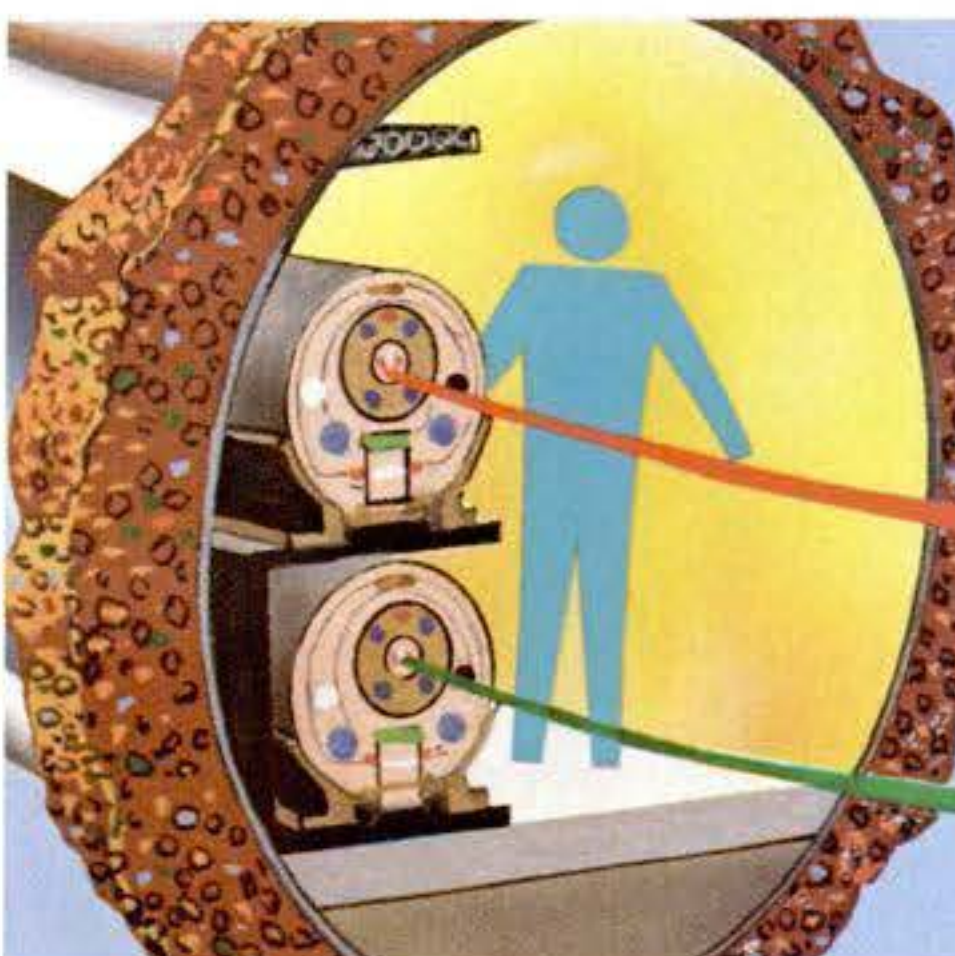
Frozen tools

After a slow descent to -300 degrees F and back to room temperature, steel and other metal tools may wear better. Yet this inexpensive process is not widely used. Why? The treatment doesn't always work, and it has not been proved scientifically. **Page 64**



World's biggest machine

If Congress approves its construction, the Superconducting Super Collider will be the largest device ever, and one of the costliest—about \$4.4 billion. Its purpose is to plumb the mysterious domains of particle physics in search of the basic entities and forces that govern the nature of all things. **Page 56**



Sliding-seat dory

A cross between a fast rowing shell and a weekend family boat, this nimble craft is built from thin plywood bonded and sealed with epoxy. No metal fasteners are used on this one-seater. **Page 84**



Pick of the pickups

These hard-working vehicles feature engines with fuel injection, anti-lock braking, top-handling suspensions, and stylish interiors. We stage a showdown between four new American pickups. **Page 26**



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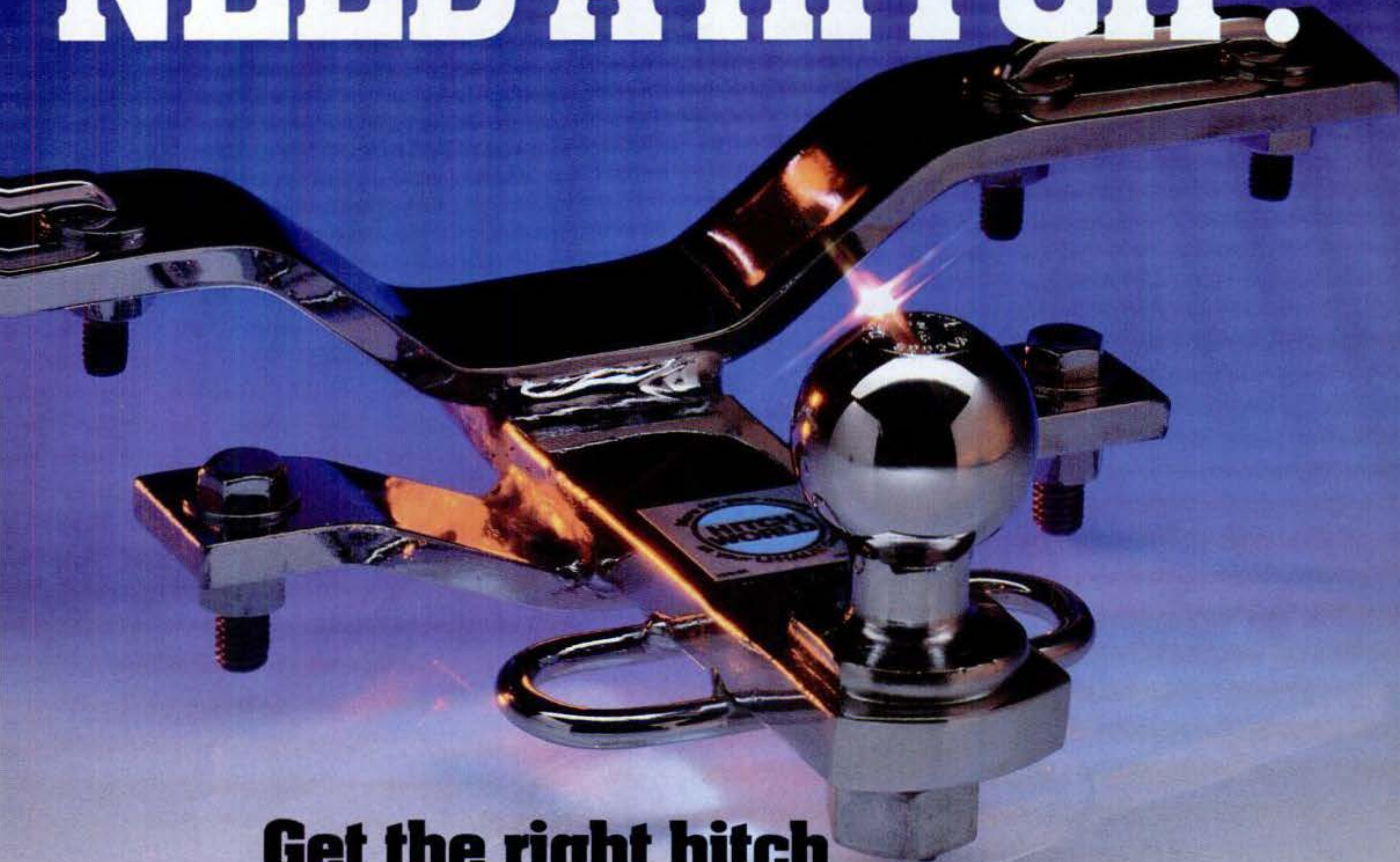
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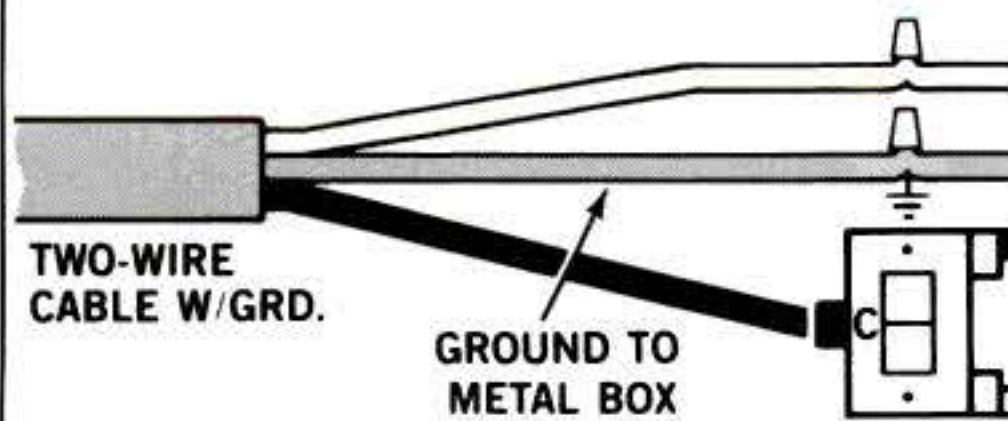
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Readers Talk Back

Multi-switch mistake



A label in your diagram of multi-switches ["Wiring Multi-Switches," Jan.] might be confusing to some people. It would seem to suggest that the black ("hot") wire should be grounded to the metal box (zap, goes the fuse), when actually the green (bare) wire is the one to be grounded to the metal box.

Paul Duerr, Tucson, Ariz.

Right you are—an arrow was left off the artwork. The grounding symbol to the box is correctly shown as a pig-tail from the green wire in the center.
—Richard Day

Two-stroke meets emissions

I read with interest your article "Can the Two-Stroke Make It This Time?" [Feb.], but I don't agree with the statement that no motorcycle or automobile with a two-stroke engine can pass emissions tests. The Yamaha RZ-350 is a two-cylinder two-stroke motorcycle that has been in the U.S. since 1984.

B. Wilborn [no address]

You're right. Yamaha offered the 350-cc two-cylinder two-stroke RZ-350 motorcycle during the 1985 and '86 model years. It was equipped with a small catalytic converter that made it emissions-legal in all 50 states. The model was discontinued due to slow sales, although some leftover bikes may still be in dealers' showrooms. A Yamaha spokesman said that a similar engine could be built to meet 1987 emissions standards if there was demand for it.
—Stuart Brown

Sometimes late, but alive

As a pilot who has spent over three years in the air, I enjoyed your article on wind shear [March]. My experi-

Address letters for this column to: Readers Talk Back, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. We are unable to acknowledge unpublished letters.

ence confirms Tetsuya Fujita's determination that typical microbursts are "about a mile across, lasting about 10 minutes." But when he says, "... there's no way a pilot can fly around all of these small rain clouds," he is mistaken. If "wet microbursts are associated with ... a rain shaft marking the spot where the microburst descends," and the Huntsville study showed that "one hundred percent of the microbursts occurred in heavy rain," wouldn't it be prudent to avoid that heavy rain? A 30-minute holding delay is a lot easier to explain than 135 killed—including the pilot. The conclusion we can draw from this fine report is that any captain who elects to land when there's a thunderstorm within five miles of the runway—especially at the approach end—is asking for it, because in less than half an hour the danger will no longer exist.

Bud Eleson, Belmont, Calif.

Canada's the SPOT

In your February article "SPOT-ing Earth from Space," you failed to mention two important receiving stations, located in Canada—Gatineau, Que., and Prince Albert, Sask. All of the U.S. coverage is recorded at these two stations: the East Coast and Central States at Gatineau and the West Coast at Prince Albert.

Simon Methot, Kanata, Ont.

Put the right shoe forward

In March's "Car-Care Quiz" I was confused about the first problem concerning brake-lining wear-down. The description of the problem seems accurate; however, the drawing accompanying it shows the vehicle in reverse gear (according to the rotation arrow) when your description is applied to it. Was the drawing used to show the error or the correct application?

L. V. Nease III, Savannah, Ga.

The drawing shows the error. The trailing shoe was installed facing forward, which caused the rapid lining wear.

Cheaper short detector

In your February article "Short Circuits," Bob Cerullo mentions a short-circuit detector called Shortell. I'm sure this is a fine tool, but \$70 may

Continued

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Why Passport is the most expensive* radar detector in the world

What sets Passport above other detectors is the technical reach of our engineers, and their insistence on excellence at every design step. *Road & Track* called us "the industry leader in detector technology." Here's why:

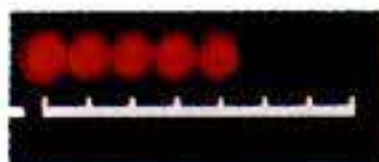
Double-ridge waveguide: It was always taken as gospel that miniaturizing a detector would hurt performance. Passport proved this wrong. The miniaturized horn antenna feeds into a double-ridge waveguide. Dual compound chokes are required, and the notch filters are press fit to exact depth. The design process was incredibly complex. But the payoff is indisputable. Passport's performance is uncompromised by its discreet size.

Rashid rejection: In another engineering first, our detectors have been made immune to K-band signals transmitted by the Rashid VRSS collision warning system. Other detectors produce false alarms in the presence of Rashid. Our AFR™ (Alternating Frequency Rejection) circuitry isolates and neutralizes Rashid signals, yet leaves the radar detection capability undiminished for your protection.

X-K differentiation: Passport has separate warning tones to distinguish X-band from K-band. The difference is important. Traffic radar is just one of many transmitters assigned to X-band by the FCC. Motion detectors, burglar alarms and microwave door openers also share this frequency. When you hear the X-band warning, you respond accordingly.

But just two transmitters operate on K-band — radar and Rashid. K-band radar's short effective range requires immediate response. Since our AFR circuitry rejects Rashid, Passport's K-band warning is positively radar, and you always know how to respond.

Variable-rate warning: On radar contact, Passport's bar graph of eight Hewlett-Packard LEDs indicates radar strength, and you



will hear the audible warning — pulsing slowly at first, quicker as you approach, then constant as you near effective radar range. Our engineers have preprogrammed the warning system to tell you everything you need to know about radar. Passport asks no further programming of you, unlike many lesser detectors.

SMD circuitry: Passport's miniaturization was made complete by the use of SMD's (Surface Mounted Devices), micro-electronics common in satellites but long considered too exotic for radar detectors. SMD circuit boards also provide ruggedness unobtainable with conventional technology.

Compact dimensions: Passport was designed to be the most discreet detector ever — only 0.75" H x 2.75" W x 4.50" L. On guard, it never draws attention to itself.

Die-cast aluminum housing: The antenna is integrated into Passport's die-cast SAE 308 aluminum housing. This way no amount of abuse can ever shake the antenna

loose, and Passport's precision electronics are protected by a rugged metal vault for durability under extreme conditions.

Nextel finish: The alloy housing is finished in charcoal Nextel — a light-absorbing coating — to eliminate all possibility of reflection and glare.

Twin speakers: A fully adjustable volume control allows you to set the loudness of the audible warning from twin speakers. The warning tone is 1024 Hz, identical to that used for Morse code, for maximum clarity yet minimum annoyance.

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be a little steep for the average home mechanic. From the description in the article, this tool seems to resemble a short-circuit detector made by K-D Tools (model KD2524) that retails for around \$15 at any auto-parts store selling K-D tools.

Gary A. Smith, Visalia, Calif.

You're correct. Easco K-D Tools (3575 Hempland Rd., Box 3767, Lancaster, Pa. 17604) does sell a short-circuit detector. The suggested retail price is \$20.30. It's not as elegant as the more expensive Kent-Moore Shortell, but it works in much the same way.—Tom Wilkinson

Rear-feed printers

I think the design in April's "Wordless Workshop" for catching pages as they leave the printer is a very good one, but there is one problem. Most printers do not accept the feed paper through the bottom, but from the rear instead.

Tony Alviar, Ohiopyle, Pa.

Dividing up the pi

After reading the short article in "Electronics Newsfront" [March] And the Answer Is . . . , I read in *Science News* that the Japanese have computed pi to 134,217,700 digits. That's quite a far cry from the 29,360,128 digits you reported. Although it took the Japanese about two days to compute, it is still proportionally far greater than what the Cray-2 has produced. Will the Far East continue to surpass us so quickly in electronics?

Jeff Daly, Ames, Iowa

Before this letter is printed, the record will likely be beaten again.

Trickle-down safety

In the January 1980 *POPULAR SCIENCE*, there was an article ["High-Tech Cars for the Mid '80s"] on two research safety vehicles, Calspan Corp.'s RSV and Minicars Inc.'s gull-wing RSV. What ever happened to those cars? Will they ever be sold?

Bill Weaver, Seattle, Wash.

Safety car programs tend to come and go with availability of government funding. Though the RSVs never got close to production, many of their features have been incorporated into today's cars. Energy-absorbing body structures are now common; and electronically shifted transmissions, anti-lock brakes, and air bags are available

on many cars. Other ideas like run-flat tires and radar braking are still under development and may appear in the future.—Tom Wilkinson

\$400 richer

Replacing all ignition parts and adjusting the carburetor failed to correct the rough idle on my 1977 Oldsmobile Delta 88. A compression test indicated it might be time for a \$400 valve job. Fortunately, I waited, because your December '86 "Car-Care Quiz" saved me the money. After reading the entry on rough-idling engines, it took me five minutes to discover the real problem—a 3/4-inch crack in the cruise-control vacuum hose at the intake manifold. Thanks again!

Russell L. Miller
Douglasville, Ga.

ROVAC revived

I am writing in response to the November 1986 "RTB" letter inquiring about the ROVAC air-conditioning system. A recent letter mailed to ROVAC stockholders included the following information: From late 1983 to late 1984 "a small research group at Stafford Industries in Rochdale, Mass., favorably evaluated the ROVAC technology. Management at Stafford believed that ROVAC's technology could be applied to new business opportunities in several industries, including air conditioning, heat pumps, air compression, and small-scale electric power generation." The letter adds that ROVAC is back in action, "developing for manufacture small-scale Rankine power plants that will produce electricity from hot water or low-grade sources of heat, and high-efficiency heat pumps."

Phillip Lehrbaum
White Plains, N.Y.

High-priced candidate

In your April car test, why did you include the Mercedes-Benz 300E—which costs about \$18,000 more than the Sterling and \$13,000 more than the Cadillac—rather than the 190E Benz, which is in the \$25,000 price range?

William P. Miller, Pensacola, Fla.

We chose the 300E because it is similar in size and performance to the Sterling and Seville, whereas the 190E is a good bit smaller. Also, we tested a 190E in August 1986, and we like to fit as many different cars as possible into our test schedule.—Tom Wilkinson

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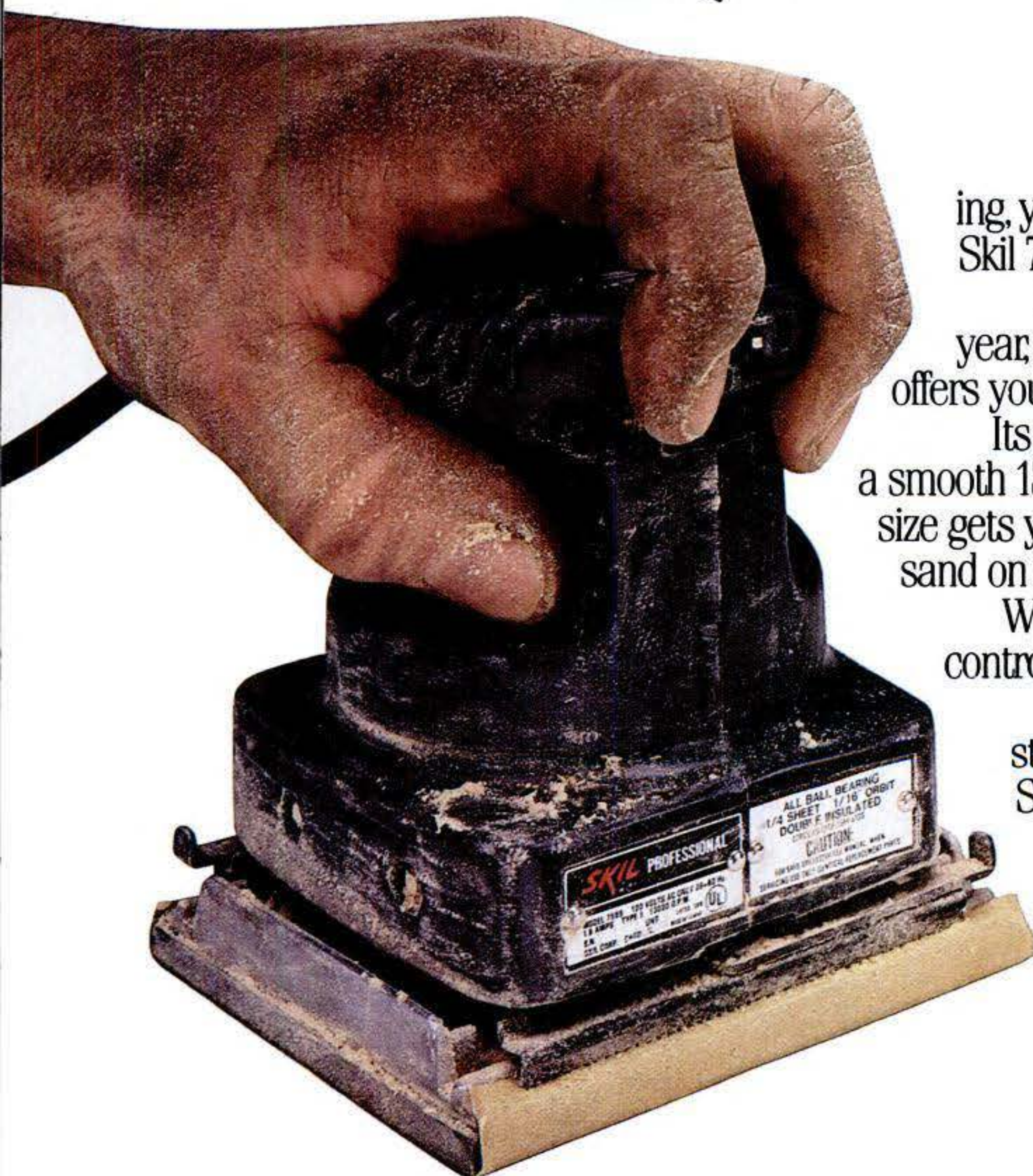
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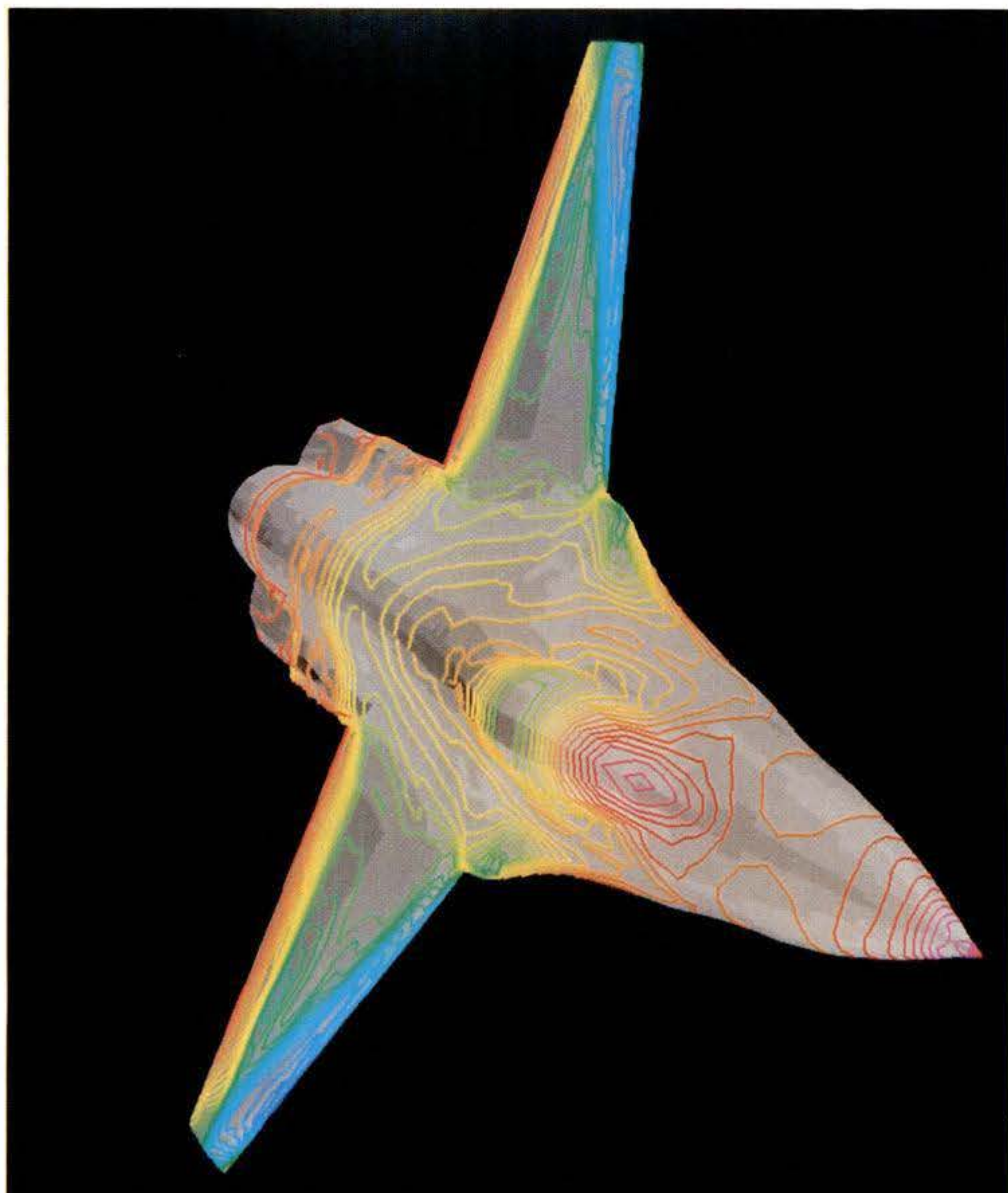


16 mg "tar," 1.0 mg nicotine
av. per cigarette, FTC Report Feb. '85

SURGEON GENERAL'S WARNING: Quitting Smoking
Now Greatly Reduces Serious Risks to Your Health.

Science Newsfront

By ARTHUR FISHER



A NASA supercomputer generated this pressure flow study of an F-16 plane.

Super-duper computer

Last March the world's most advanced supercomputer system became operational at NASA's Ames Research Center in Mountain View, Calif. Named the Numerical Aerodynamic Simulator, it will be devoted primarily to cutting-edge exploration of aeronautical design. One example is this simulation (above) of the pressure contours over the body of an F-16 fighter traveling at a speed of Mach 0.9. But the system will also be used to grapple with a wide variety of problems requiring major increases in computer power, such as genetics research, modeling the weather on Earth and other planets, simulating complex chemical and physical cycles, and studying the formation of galaxies and other

cosmological puzzles [see "Solving Unsolvable Puzzles with Supercomputers," May].

The Ames system is one that will evolve. At any given moment, it will use the two fastest supercomputers in existence. It is now being driven by the most advanced version of Cray Research's Cray-2, which can perform a steady 250 million calculations per second and has a stupendous 256-million-word internal memory. Later this year NASA will acquire a second supercomputer, which will boost the system's capability to a sustained one billion calculations per second.

Pluto shrunk

Pluto, the most remote and mysterious of the solar system's planets, is

even smaller than recently thought. Two German astronomers from the Berlin Technical University, working at the European Southern Observatory on Mount La Silla, Chile, report that they have accurately measured Pluto's diameter for the first time. Their finding: 2,200 kilometers.

Manfred Pakull and Klaus Reinsch tracked the path of Pluto's moon, Charon, as it circled the planet. Analysis of the changes in light readings from Pluto's surface led to the new calculations, which also show that Charon's diameter is 1,160 kilometers, and that it moves around Pluto in a near-circular orbit at a distance of 19,000 kilometers. In this weird system Charon accounts for 13 percent of the planet-moon mass. Earth's moon accounts for no more than one percent of the Earth-Moon mass.

Superconductor surprises

The world of physics is in a turmoil unseen for many years. The reason: The discovery of superconducting materials whose transition temperature—the point at which they lose all resistance to the flow of electrical current—is far higher than ever achieved or even thought possible before now.

For more than 60 years after the phenomenon of superconductivity was first discovered (by Dutch physicist Kamerlingh Onnes, in 1911), experimenters were unable to make a superconductor that would operate above a frigid 23 degrees Kelvin, or -419 degrees F. The materials must therefore be cooled by liquid helium. But since last December there has been blinding progress with the development of new ceramic materials. As of this writing, a complex oxide has proved to be a superconductor at an astonishing 95 K, well above the boiling point of liquid nitrogen, which is 77 K. Liquid nitrogen is a cryogen that is far cheaper and easier to use than liquid helium.

The implications are stupendous. High-temperature superconductors could lead to vast improvements, at feasible costs, in microprocessors, medical imagers, magnetic-levitation trains, supermagnets, electrical transmission lines, and supersensitive detectors. I'll report fully on this dramatic development in a future issue.

Continued

THE WINDS OF CHANGE ARE BLOWING AT CHEVROLET

CORSICA

It was conceived as a sport sedan to challenge the compact market.

It resulted in a sport sedan more aerodynamic than either Porsche 928S or Ferrari Testarossa.

A sedan whose engine not only monitors itself, it monitors the driver.

A sedan whose manual 5-speed shifts so smoothly, it's almost automatic.

A sedan whose rear wheels help steer through turns.

A sedan whose front seats give people in back more room.

A sedan which, once it's painted, gets painted again.

Introducing the new 1988 Chevrolet Corsica, from The Heartbeat of America.

Put yourself into the smoothest Chevrolet sedan ever built.

And listen to your heart beat.

And the winds of change blow.



THE
Heartbeat
OF AMERICA

 TODAY'S CHEVROLET

Let's get it
together...
buckle up.



See your Chevrolet dealer for terms and conditions of the new limited powertrain warranty.



Thermal imaging—literally, taking pictures of the heat distribution within a

body—is helping physicians study the causes of rheumatic diseases.



An astronaut assumes the neutral body posture aboard the space station.

Diamonds from space

Researchers at the University of Chicago have found—serendipitously—microscopic diamonds from beyond the solar system. The tiny gems were embedded in meteorites, and predate the birth of the sun and Earth.

Roy Lewis of the university's chemistry department and Edward Anders of the university's Enrico Fermi Institute report that the diamonds were formed in the atmosphere of a distant star and then spewed across space when the star exploded. They have remained chemically unaltered for more than 4.5 billion years.

"This work," says Anders, "suggests that the formation of diamond occurs on an enormous scale in the universe."

Thermal imaging

Doctors at the Royal National Hospital for Rheumatic Diseases in Bath, England, are using the experimental equipment in the photo above to explore the potential of thermal imaging (analyzing the heat distribution in the body) in researching the origins of rheumatic ailments. The patient's pressure sore, caused by long periods of being bedridden or wheel-

chair-bound, is being studied with a portable camera that allows a physician to combine conventional filming with thermal imaging. The resulting thermograms have exceptionally high resolution.

Bacterial missing link

The National Science Foundation has announced the discovery of a unique bacterium that acts as a natural fertilizer and may be the descendant of an ancient "missing link," the immediate forerunner of the cyanobacteria that released enough oxygen to form Earth's life-sustaining atmosphere. The unique bacterium, *Heliobacillus mobilis*, was found in rice paddies in Thailand by an Indiana University research team headed by professor of biology Howard Gest.

Cyanobacteria were until recently called—incorrectly—blue-green algae. The heliobacteria fix nitrogen about 10 times faster than cyanobacteria and multiply six to 18 times faster.

Giant galaxy

Astronomers have discovered the largest known heavenly object outside of a galaxy cluster: a spiral galaxy 13

times larger than the Milky Way, 1.3 million light-years in diameter, and 300 million light-years from Earth in the direction of the constellation Andromeda. The astronomers are Susan M. Simkin of Michigan State University; Jacqueline van Gorkom of the National Radio Astronomy Observatory in Charlottesville, Va.; Su Hong Jun of the Purple Mountain Observatory in Nanjing, China; and John Hibbard of the Very Large Array. The observations were carried out at the Very Large Array, a network of 27 radio telescopes near Socorro, N.M.

Space bodies

The drawing above, showing what seems to be a singularly relaxed individual, represents the posture a space denizen would adapt in a zero-gravity environment. It is called "neutral body posture," and along with many other aspects of the human body, is one of the determinants in the design of the habitat modules for this country's space station, to be launched by NASA in the early 1990s. The drawing was prepared by Boeing Aerospace Co., one of the firms competing for the role of designer and builder of the station's living and working quarters. **PS**



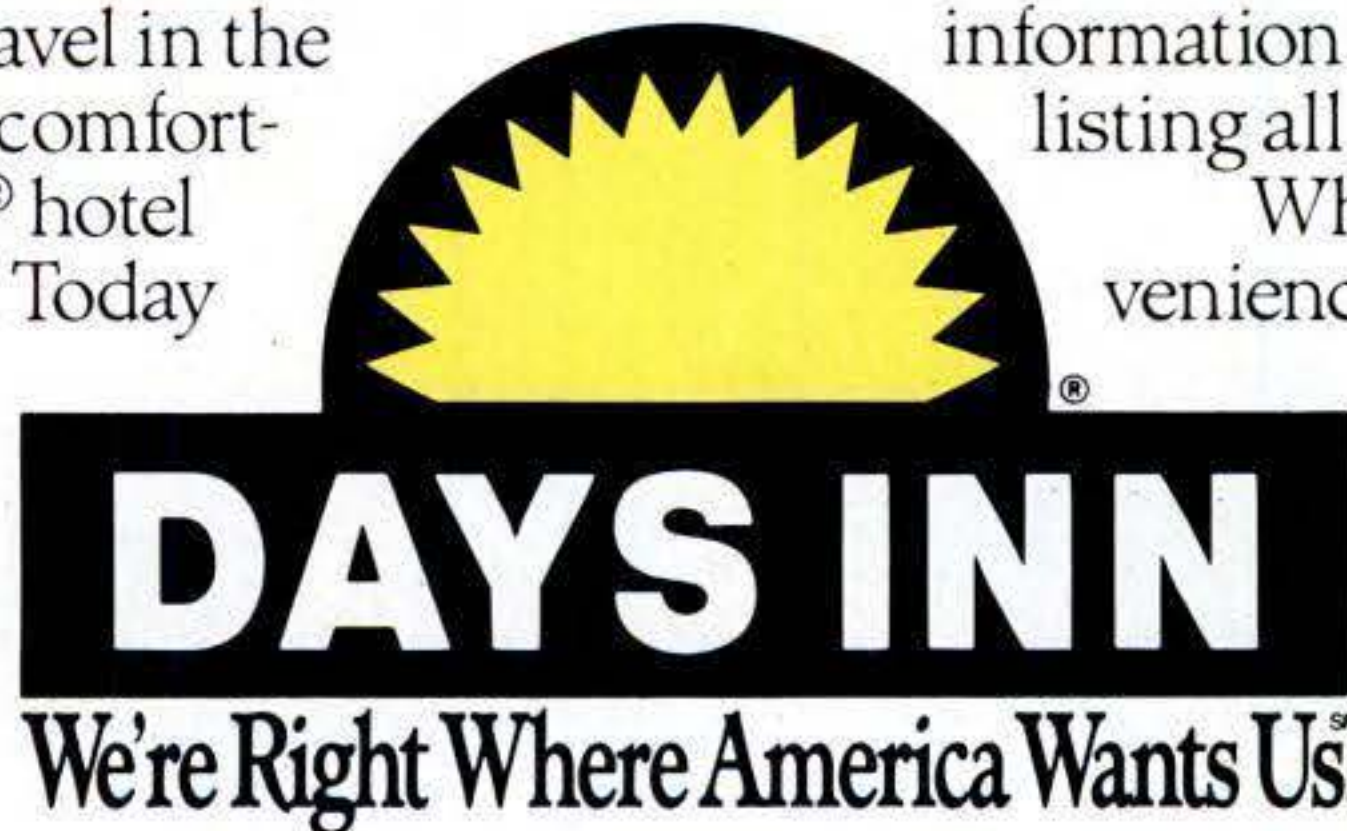
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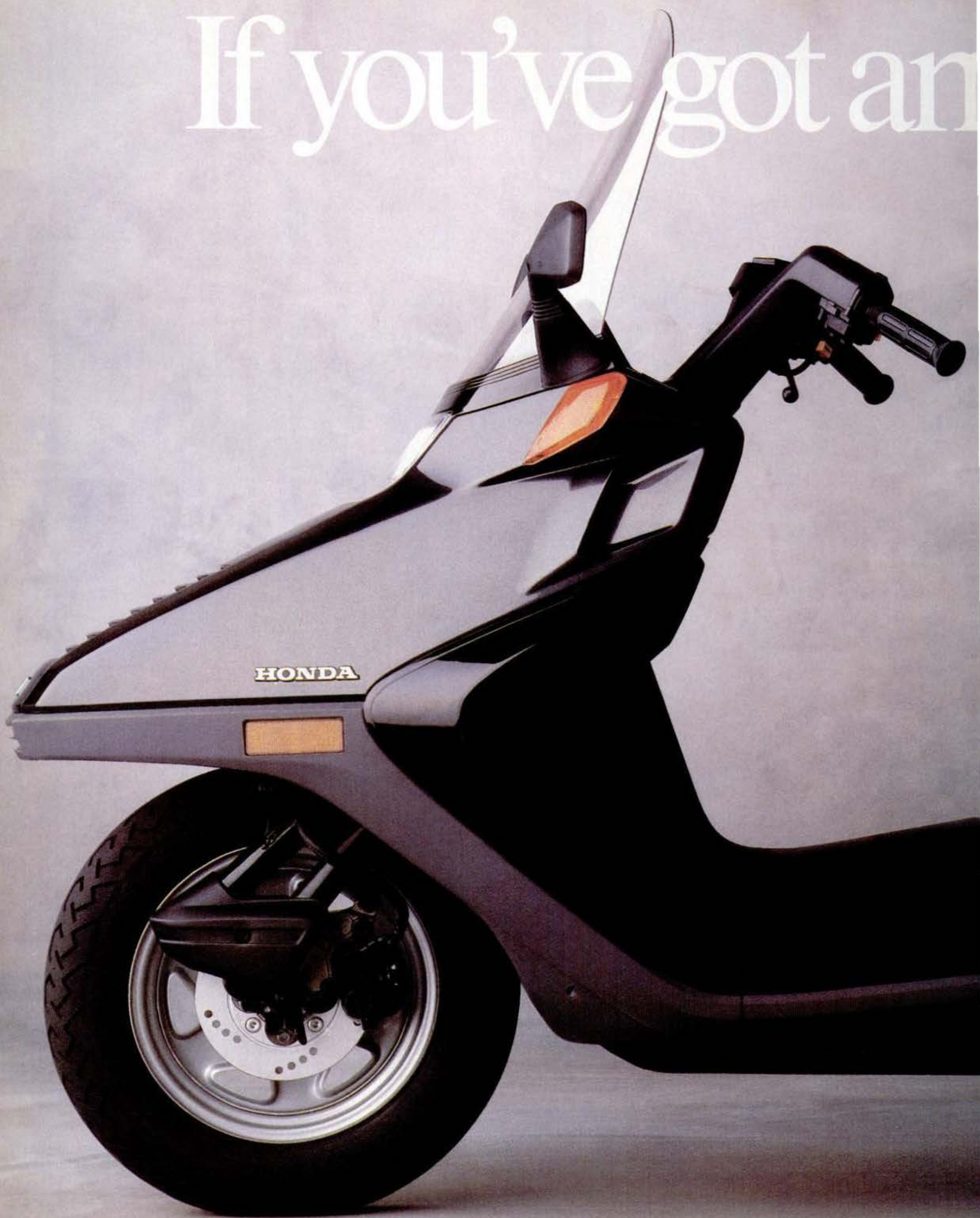
When it comes to price, convenience and a clean, comfortable room, "we're right where America wants us." And when you can find a Days Inn hotel right where you want it, why look anywhere else?



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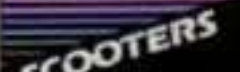
The Honda Helix.[™] Push-button starting. Automatic transmission. Advanced digital instrumentation. When

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itch, scratch it.



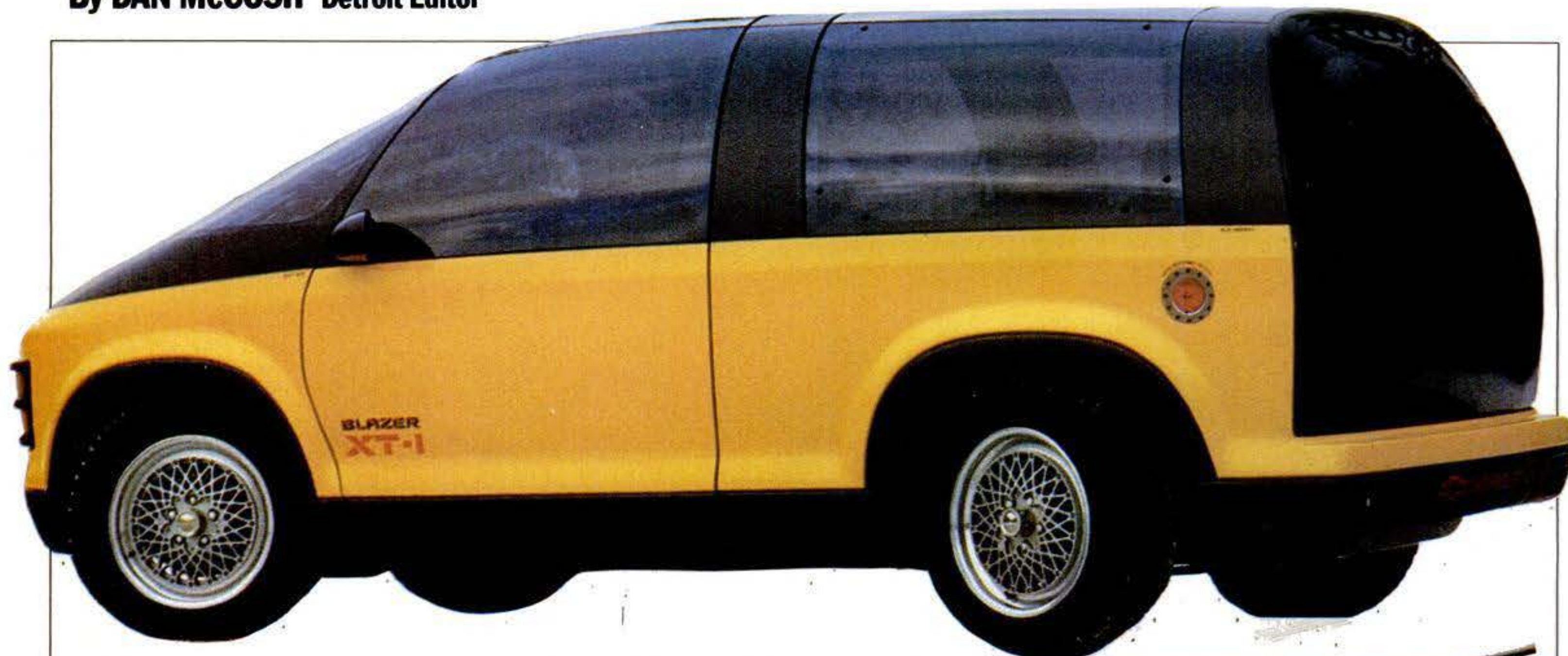
you've waited long enough, call 1-800-447-4700 for the dealer nearest you.

HONDA  **SCOOTERS**

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Automotive Newsfront

By **DAN McCOSH** Detroit Editor



Better Blazer

Chevrolet Motor Division's new experimental Blazer XT-1, recently unveiled at the Chicago Auto Show, stands out from the recent flood of futuristic concept cars like a loaf of bread in a school of dolphins. Look again, and it's standing even higher, as its four-corner leveling suspension goes to work, raising ground clearance to accommodate shifting terrain. Then it bobs lower, curtsying at the curb to let a lady inside.

Blazer XT-1 is one of the first off-road concept vehicles to emerge from Detroit, which until now has mainly concentrated on futuristic sports cars. Fully workable, it uses an array of electronic features to ease the task of off-road scrambling. Independent, electrically controlled steering front and rear allows tight turns, and even weird crabbing maneuvers. The computer

can even sense wind gusts and adjust steering sensitivity accordingly. New Goodyear P225/65HR17 tires were designed to enhance the steer-by-wire system, which works without a direct mechanical connection between the steering wheel and driving wheels.

The four-wheel-drive power train uses a new 4.3-liter all-aluminum engine derived from the Vortec V6 in the current Chevy pickup. The transmission is electronically controlled, as is the transfer case, which includes a self-sensing unit that puts the Blazer into four-wheel drive whenever a wheel begins to spin. The same computer shifts torque fore and aft to compensate for wheel slip. Brakes incorporate Delco Powermaster III anti-lock.

Multiplexed wiring [see "Smart Circuits," this issue] and a 24-volt electrical system are also being tested on the new Blazer, and may be close to production.



Blazer XT-1's instrument panel features a three-dimensional display.

SAE brainstorm

This year's annual meeting of the Society of Automotive Engineers in Detroit lifted the cover off a sampling of new technology likely to emerge soon on passenger cars:

General Motors Corp. showed a new system that detects when engine oil needs to be changed. A computer keeps track of engine temperature and revolutions and displays a "miles to change" readout on the car's instrument panel.

Japan's Stanley Electric Co. demonstrated an LED stoplight that emits bright red light from a narrow tape that molds neatly above the rear window. Stanley also showed a new headlight that can shine through a front lens raked at 60 degrees, which would

Continued

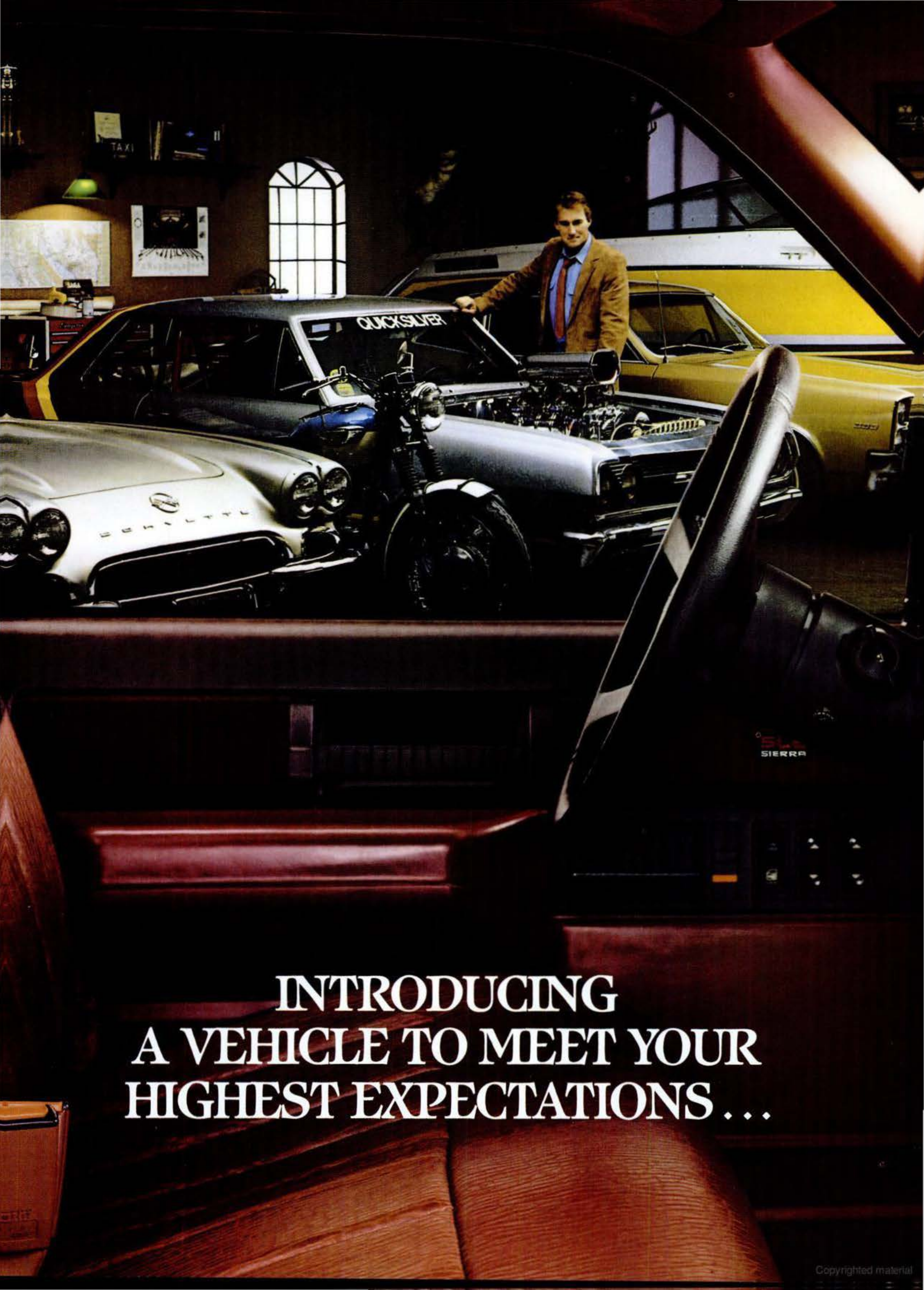


Porsche is working on a factory-built convertible of the 944, which should be available next year.

Topless Porsche

In spring, a young man's fancy turns to... Porsche convertibles? Having seen this spy photo of the upcoming 944 Cabriolet, I bet members of both sexes will soon be swooning over Zuffenhausen's latest creation: The turbo-powered two-seater is due to go on sale in the United States in mid-1988.

PHOTO BY HANS G. LEHMANN/HIDDEN IMAGE



INTRODUCING
A VEHICLE TO MEET YOUR
HIGHEST EXPECTATIONS...



... AND EXCEED THEM. SIERRA: THE ULTIMATE PICKUP FROM GMC TRUCK.

You demand a lot of your possessions.

To fit your life, a vehicle must do more than simply fit in your driveway. It must offer a sense of adventure that complements your own personal style. It must suggest endless possibilities — and then fulfill them. What you drive must be as comfortable as a broken-in pair

of jeans, and yet as contemporary as anything on the road today.

In short, you expect a lot. But you are easy to satisfy — because you only want the best. It is for individuals like you that we proudly introduce Sierra. The ultimate pickup from GMC Truck.

Sierra is clearly a new concept in full-size pickup design. Designed to

be the last word in pickups, from the first name in trucks: GMC Truck.

But don't just take our word for it. We invite you to refer to the last page of this section for a detailed explanation of Sierra.

And don't forget to bring your expectations.



SIERRA.

SOPHISTICATION YOU NEVER EXPECTED IN A PICKUP.

ALL THE ROOM, POWER AND PERFORMANCE

YOU EXPECT FROM A

GMC TRUCK.

Your expectations are high. Sierra will fulfill them. And then some.

Advanced aerodynamic lines give Sierra a fresh contemporary shape, with a rakish windshield and flush-fitting side glass for a quiet, comfortable ride. With its sophisticated styling, Sierra is ready to go everywhere. Select a four-wheel-drive model (with the Insta-Trac system that lets you shift conveniently from two-wheel to four-wheel drive without stopping) and "everywhere" can be almost anywhere!



Full-size inside.

Sierra's interior features more shoulder and leg room than previous full-size pickups from GMC Truck. So there's plenty of stretch-out space for three adults. Standard power steering and power brakes ease your driving.



And you can add almost every conceivable driving amenity, from electronic cruise control to power windows and power door locks.

Full-size outside.

In today's world of "mid-size,"

"small-size," and "downsized" pickup trucks, Sierra is a full-size pickup that still delivers the goods. Select from 6½' short-bed or 8' long-bed models. The long-bed can still accommodate the proverbial 4' x 8' sheet of plywood between the wheelhousings.

Full-size power.

The amazing 4.3-liter Vortec V-6 engine is standard (except on 3500 models which feature a standard 5.7-liter V-8). And with the available five-speed manual overdrive transmission and Vortec engine, a two-wheel-drive Sierra is rated at an impressive EPA estimated MPG city 17 and highway 23. Or you can select from a big choice of V-8s: 5.0-liter (305 cu in), 5.7-liter (350 cu in), 7.4-liter (454 cu in), or the 6.2-liter (379 cu in) diesel. Standard electronic fuel injection on all gas engines gives instant starting response and outstanding over-the-road performance. When properly equipped, Sierra is ready to move up to 19,000 lbs, including itself, passengers, trailer, equipment and cargo.

Built to be driven.

Sierra gives a whole new meaning to the phrase, "drives like a truck," thanks to a new fully independent torsion bar front suspension on 4 x 4 models or its newly improved two-wheel-drive front suspension.

The standard rear-wheel anti-lock brake system (operable only in the two-wheel-drive mode on four-wheel-drive models) is designed to prevent rear-wheel lockup and helps control skidding on sudden stops, on wet or dry pavement, loaded or unloaded.

The fuel tank is mounted between the frame rails. There's a new box-section front frame with impressive strength. And the side glass has been increased by 33% over our 1987 Full-Size Pickup, for greater visibility.

Built to last — in the GMC Truck tradition.

The majority of all exposed metal surfaces are galvanized steel, protected by deep-luster basecoat/clearcoat acrylic enamel — the same advanced

painting technique that protects some of the world's finest automobiles. An uncluttered underhood area offers impressive service access, and a new aluminum radiator reduces weight and helps prevent corrosion.

It's not just a truck. It's a new idea.

At GMC Truck, we've been saying, "It's not just a truck anymore," when we speak of our entire product lineup. And no product better exemplifies that phrase than our new Sierra.

It's not just a new pickup. It's a whole new way of thinking that says the traditional American full-size pickup can be just as advanced as any automobile on the road today, while still accomplishing all the truck-like things you usually buy a pickup for.

And every new Sierra is backed by a 6-year/60,000-mile warranty on the



powertrain and a 6-year/100,000-mile warranty on outer-body rust-through. Buckle up and visit your GMC Truck dealer for the terms and conditions of this limited warranty. (Check the Yellow Pages under "Truck" or "Automobile.")



Then, take a look at Sierra. It's like nothing you've ever expected in a full-size pickup. And everything you've come to expect from a GMC truck.

GMC TRUCK

IT'S NOT JUST A TRUCK ANYMORE.

allow it to replace pop-up designs on cars like the Corvette.

Torrington Co. showed smart bearings with sensors that electronically measure torque, temperature, rotational speed, and the presence or absence of fluid.

Using Du Pont Co.'s Delrin plastic, Credit-Card Keys Co. makes thin plastic cards strong enough to be cut into keys—handy if you lose the metal original.

Garrett Automotive Products demonstrated a ceramic-rotor turbocharger, a prototype for the fast-response unit used in a limited-production Buick GNX. Garrett also showed a variable-vane turbo that it expects to produce boost as quickly as a belt-driven supercharger.

Porsche at Indy

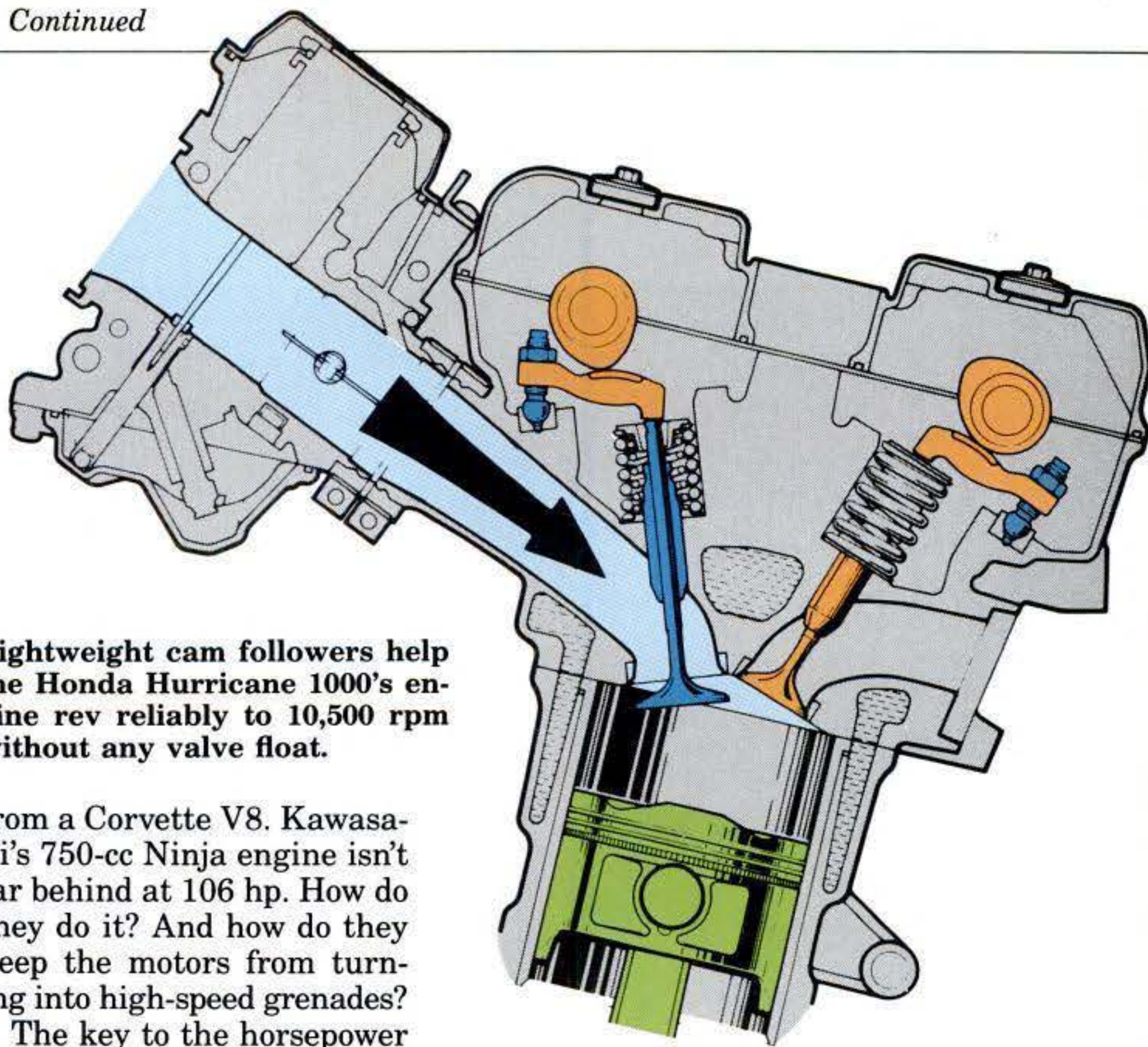
Porsche has thrown down the light-alloy gauntlet and entered the battle at the Brickyard. The German car maker is designing a car and engine to compete in the 1988 Indianapolis 500. The car's first showing, however, is tentatively scheduled for late in the 1987 Indy car season.

The engine on display at a recent Porsche preview was a 2.6-liter V8 with two cams per cylinder, a snake's nest of black exhaust tubing, and a single melon-sized turbocharger. Porsche claims the engine generates more than 700 hp and has already undergone dynamometer testing.

Porsche chairman Peter Schutz claims the company learns things from racing that it later applies to passenger cars. As an example, Schutz cited the company's recent formula-one program, which he said enhanced Porsche's understanding of combustion-chamber design and fuel efficiency.

Faster still

Honda's latest superbike engine produces 130 horsepower from just one liter. That's like getting 740 horses



Lightweight cam followers help the Honda Hurricane 1000's engine rev reliably to 10,500 rpm without any valve float.

from a Corvette V8. Kawasaki's 750-cc Ninja engine isn't far behind at 106 hp. How do they do it? And how do they keep the motors from turning into high-speed grenades?

The key to the horsepower is simple—speed. The higher these engines rev, the more air-fuel mixture they pump through their four-valve cylinder heads. But reliability is another issue. Keeping valve and cam together at speeds of 10,000 rpm or more calls for clever engineering.

Honda Motor Co., for example, trims the reciprocating weight of the Hurricane's valve train by locating screw-type adjusters on the pivot end of the cam follower rather than on the valve end as in many auto engines. Kawasaki Heavy Industries uses a similar design. Both designs reduce inertia, which helps prevent valve float, yet allow quick, easy valve lash adjustment.

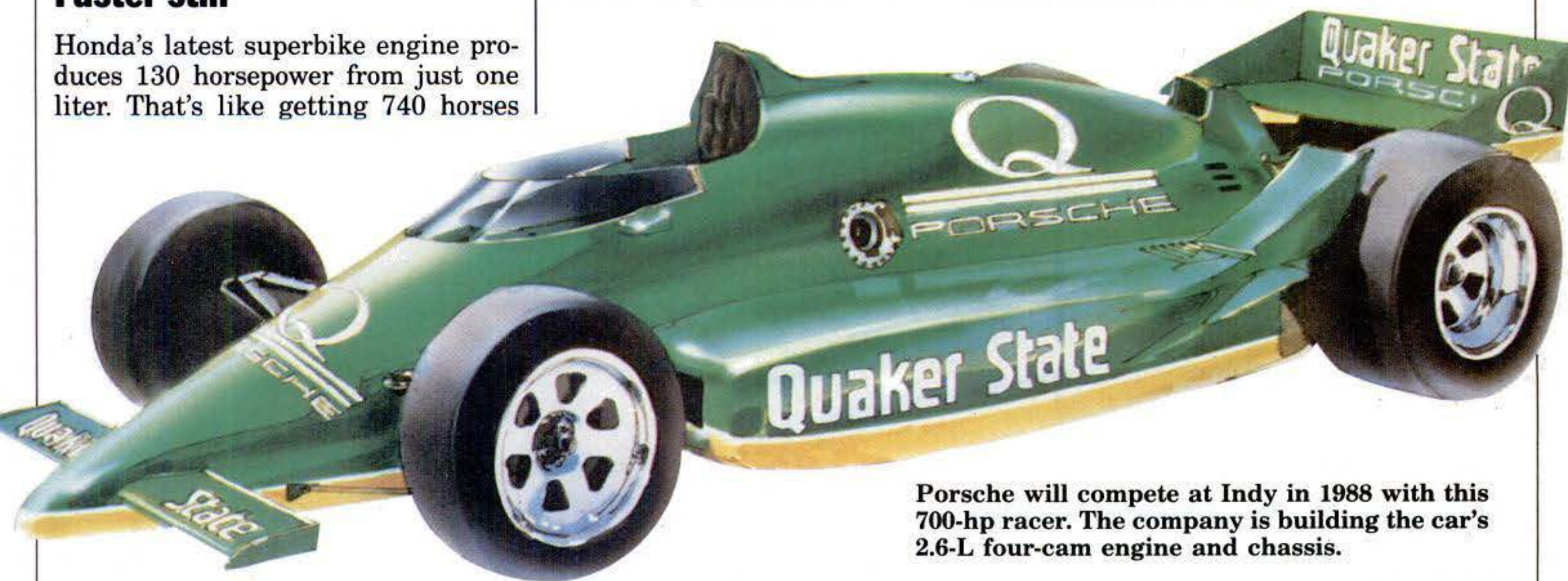
Why so much fuss over something as small as a cam follower? Kawasaki claims that, with its hollow camshafts

and lightweight valves, the 750-cc Ninja engine will wind reliably to an unnerving 14,500 rpm. At that speed, little things mean a lot.

Worldwide Escort

The next version of the Ford Escort, currently the highest-volume subcompact in the world, will be designed at Ford Motor Co.'s engineering center in Japan; however, it will be built in the United States as well as several overseas locations. The Escort will be part of Ford's newly revived "world car" program, which involved designing standardized cars that can be produced with common components in various parts of the world. **PS**

Contributors: Stuart F. Brown, Jack Keebler, Tom Wilkinson (New York)



Porsche will compete at Indy in 1988 with this 700-hp racer. The company is building the car's 2.6-L four-cam engine and chassis.

Electronics Newsfront

By WILLIAM J. HAWKINS



Panasonic's robotic portrait maker "sees" its subject and in minutes converts the data into Japanese brush art.

Portrait maker

Mention computer graphics, and I think of a computer that "draws" pictures. It doesn't really draw, of course. That would take thought, creativity, and human skills beyond the scope of machines. The computer is merely mimicking the work of a clever human programmer or artist, right? Before answering, read about a computer that writer Mitch Gould discovered...

ATLANTA, GA.

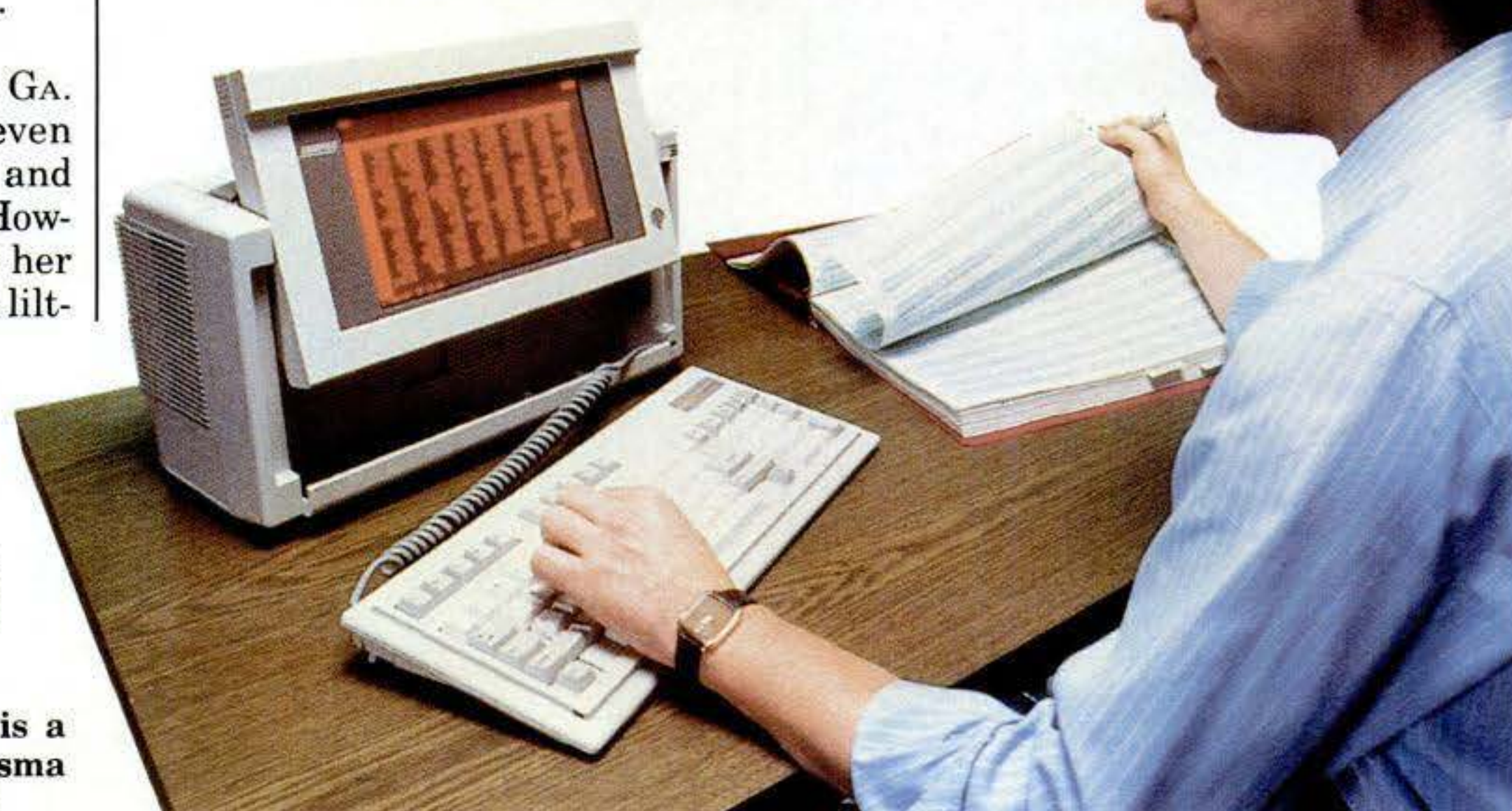
"The beret-capped artist was even shorter than Toulouse-Lautrec, and had only one arm and one eye. However, she made no apologies for her disabilities, and greeted me with a lilt-ing, feminine voice. She bowed deeply and asked me to look into her TV camera.

"Despite all her training in Japanese etiquette, I could tell she was only a machine—but what a machine! This was one of

Japan's most renowned portraitists—an impressive combination of silicon with robotics—making her American debut here in Atlanta. I had dropped what I was doing to make an appointment because I knew of her by reputation: In 1985 she had drawn crowds (pardon the expression) at Japan's Tsukuba Science Expo.

"She needed only about 30 seconds to commit my features to memory, and

then invited me to sit in a more comfortable chair as she worked. Her programmers trained her well to concen-



Compaq's Portable III computer is a 7.8-by-9.8-by-16-in. unit with a plasma display and detachable keyboard.

Any metal worth painting, is worth protecting.

trate on special features such as eyes, facial outlines, and hair. Before dipping her brush in ink, she sat quietly and furiously mapped out in her head an approach to the contours of my face.

"After approximately a minute, she had crunched an encyclopedia-ful of numbers. She then gave me a preview of her work on a computer monitor: the image of my face as it would have appeared on an early-model copy machine, with black lines marking the edges of dark features like my hair and whiskers. Then she picked up her brush and began to draw with bold confident strokes, starting with the outline of my face and hair and moving on to my eyes and nose. Occasionally she would pause as if considering the best curve—but only for a moment—and in a short time I was holding a Japanese brush drawing of myself.

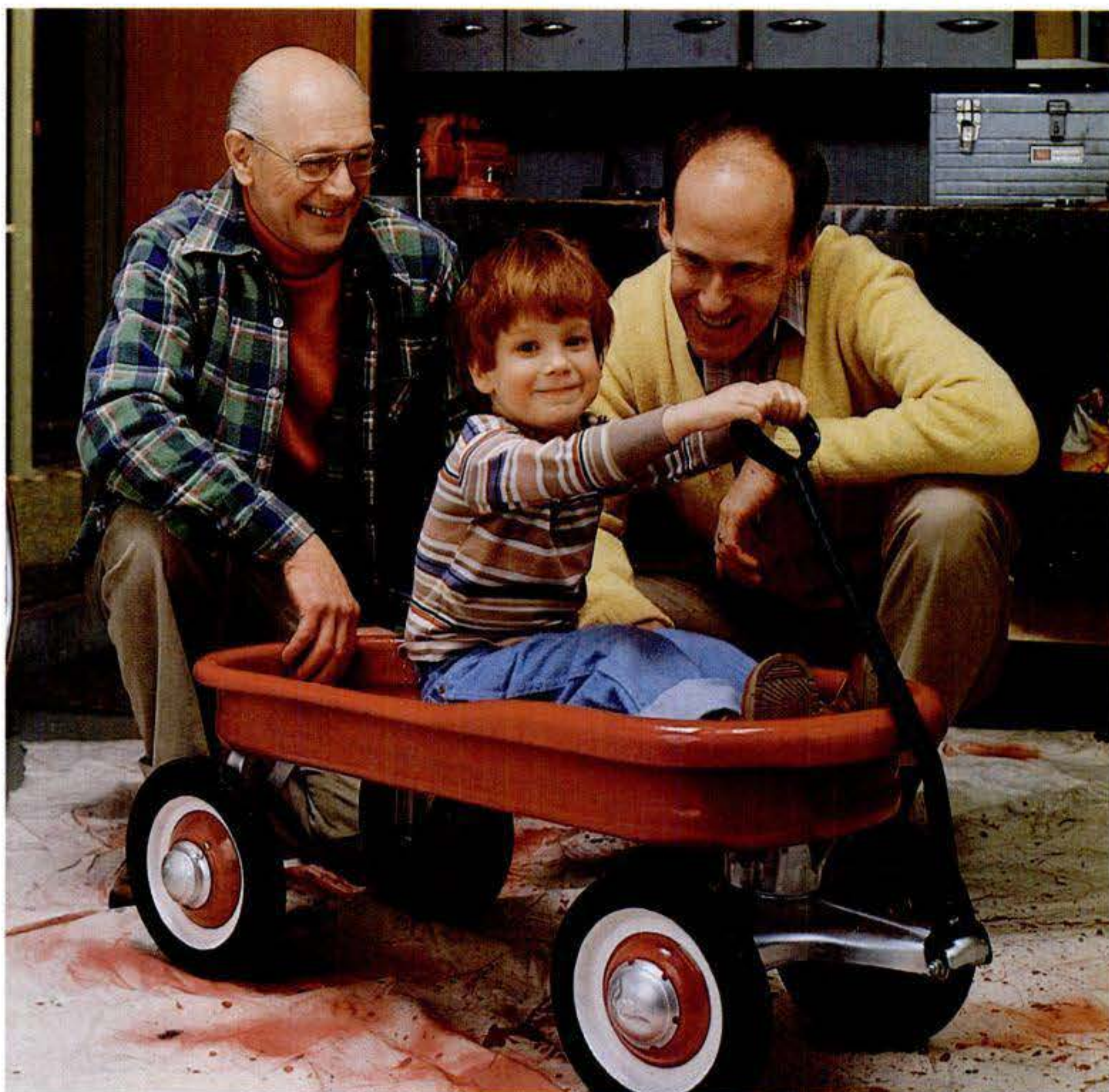
"Behind the curtain of this Oz-like Panasonic rack-mounted system, I saw some of the company's industrial computers, including an image-processing unit used for factory automation.

"The most fascinating aspect of the system was not the graceful robotic arm that actually drew the picture, but the software—powerful enough to understand a human face. After all, how do you explain to an unfeeling silicon chip which of the shadows on a TV screen are most important? One of her strangest knacks is an uncanny ability to use thick and thin brush strokes for just the right emphasis.

"The program, which occupies 256 kilobytes of memory, is written in C and assembly languages, but I couldn't help putting that technical jargon in perspective. Take a sheet of paper and draw an accurate freehand portrait of a loved one. Now, once you get it perfect—if you ever do—speed up the process down to a matter of three minutes, same as the Panasonic portraitist. Artificial intelligence, indeed."

80286 portable

Compaq Computer Corp.'s Portable III is an 18-pound portable (photo on previous page) that has up to 6.6 megabytes of random-access memory, a built-in 40-megabyte hard disk, and a 12-megahertz 80286 microprocessor. Its plasma display is capable of showing up to 640-by-400-pixel graphics and on-screen shading with text highlighting. Prices start at \$4,000. **PS**



Your father gave you that wagon for your fifth birthday. Now it's your turn to pass it on.

Any spray paint could make it red again. If that's all you wanted.

But Rust-Oleum, with an average of 50% more protective ingredients than its nearest competitor, can do more.

Its protective formula not only prevents rust, it also gives metal better protection from chipping, peeling and fading than other spray paints.



RUST-OLEUM
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***We've put the oil that protects
Bobby Allison's race car
in a very unusual place.***



Your favorite store shelf.

For this kind of torture, Bobby Allison, Bobby Hillin, Jr., and the Miller American /Stavola Brothers Race Team need one specially-formulated motor oil. So it's no surprise they use Pennzoil P•Z•L® Turbo 10W-30.

What is surprising, is the tough oil you'll find on this team, is the *same* tough oil you'll find on your favorite store shelf.

And that makes P•Z•L® Turbo 10W-30 a welcome surprise. For owners of *all* turbo and non-turbocharged cars.

It exceeds the toughest automotive engine oil requirements in the world. And it's been rated as superior by a leading national consumer testing group.

It's the oil that protects in *any* temperature, even the extreme temperatures found in today's turbocharged engines. Plus, it fights against engine oil thickening, corrosion, and wear.

So the next time you reach for turbo protection on your store shelf, reach for the oil that protects at NASCAR. World Class P•Z•L® Turbo 10W-30 Motor Oil.



*The Standard of Protection
Since 1889.™*

Optical-fiber gyro

A new lightweight, compact gyroscope could replace the heavy precision flywheel devices used in aircraft and ship navigation—with its use expanding to robot and car navigation. The gyro uses laser light and solid-state components to sense movement.

By DAVID SCOTT

Imagine a gyroscope so inexpensive that it could bring reliable in-car navigation down to the price of a quality stereo—or so small and responsive that it could provide accurate positional data for industrial robot arms. These applications and more, including aerospace and weapon navigation, could soon be possible with a new compact, inexpensive gyroscope composed of ultra-thin glass-fiber coils.

Aircraft and ship navigation systems depend on a gyroscope to sense movement and feed-in directional information. The standard gyroscope is a motor-driven flywheel that resists attempts to tilt its axis of rotation with angular momentum. Such devices are expensive and may require delicate suspension.

Now, a number of firms are designing a coiled-fiber gyroscope that can do the job for less than one-half the cost. Light and compact (with most components integrated on a single chip), these fiber-optic gyros have no moving parts, so they're rugged and maintenance free. According to Dr. Michael Bone, one of the project scientists in the Integrated Optics Laboratory at Britain's Standard Telecommunications Laboratories (STL), "These gyros are extremely sensitive and can register rotation rates as small as one-tenth of a degree per hour. At the other extreme, they're capable of accurately measuring very high, sustained rotation rates of over one thousand degrees per second. No mechanical gyro could do that."

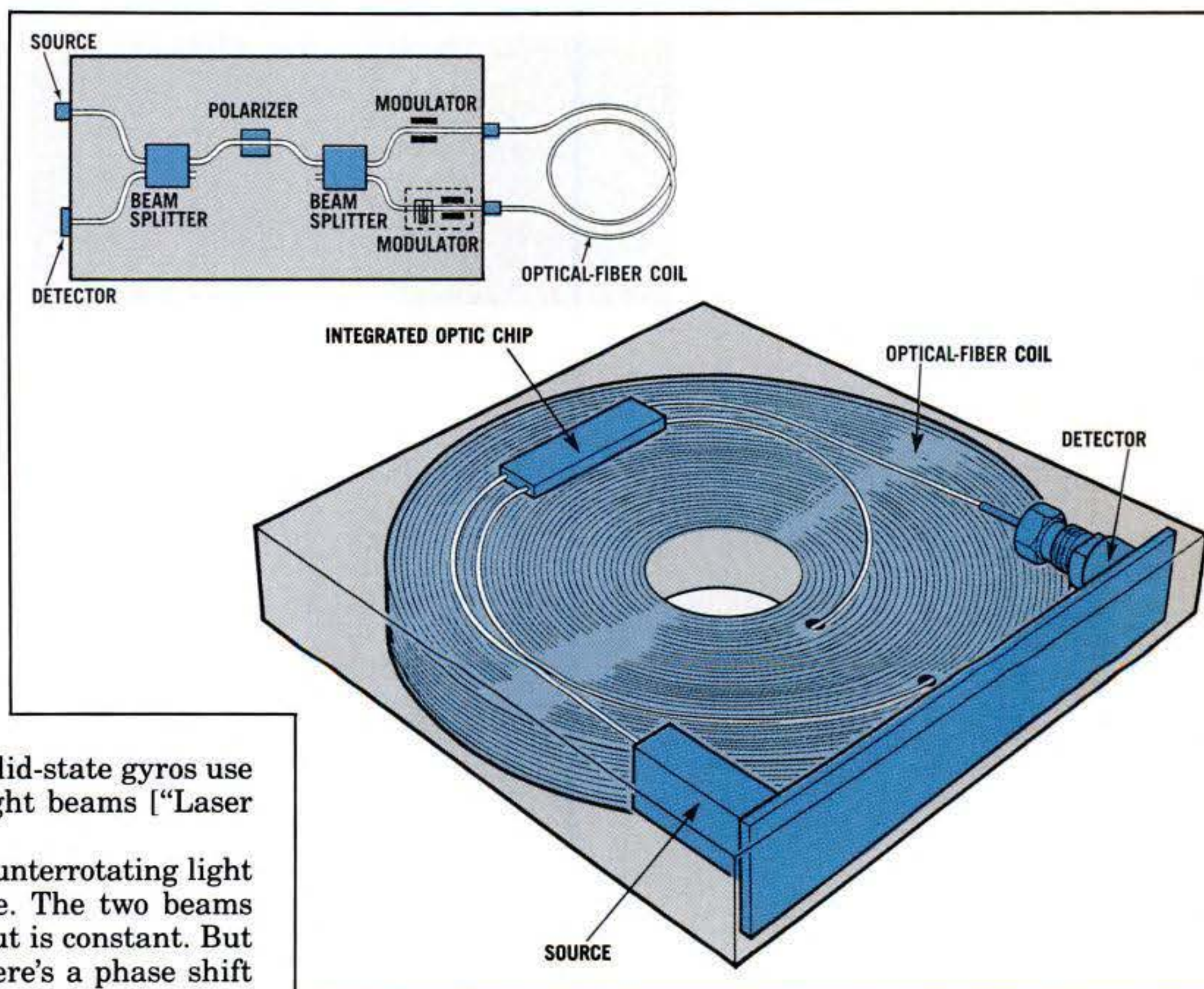
The basic idea is simple. Light from a laser source is split into two beams, then polarized and launched into opposite ends of a coiled length of hair-thin glass fiber. The two beams spiral around the coil in opposite directions and are reunited when they emerge from the fiber ends. Light output is then detected by a photodetector and converted to electrical voltage. Other solid-state gyros use mirrors instead of fibers to channel light beams ["Laser Gyroscope," Jan. '82].

When the coil is stationary, the two counterrotating light beams are equal but opposite in phase. The two beams cancel out each other, and voltage output is constant. But when the coil is turned on its axis, there's a phase shift between the two light beams. The beam that circulates in the direction of coil rotation now has to travel farther through the fiber (a longer propagation time), while the reverse beam's path is shorter. The beams no longer cancel each other upon reuniting, and the resulting voltage change is proportional to the rate of rotation.

Several companies have independent projects for a solid-state gyro, differing only in detail. The STL design uses a 500-yard length of ultra-fine glass fiber wound into a three-inch-diameter coil. The light source is a mini-laser, and all optical components, including beam splitters, polarizer, and modulator, are integrated on a single optical chip.

This chip, only 1 millimeter (0.04 in.) thick, is made of lithium niobate, and operates similarly to those for conventional integrated circuits. "A practical navigation system would require separate gyros to sense movement in three axes, and the optical parts for all these could be combined on the same chip," says Bone. "The next step will be to integrate the signal-processing electronics into the chip configuration," he explains. "This would make the optical-gyro package very small indeed."

Such compactness and direction-sensing capability should mean a big role for the optical-fiber gyroscope in vehicle navigation and guidance systems. For aerospace, the gyro's low weight and resistance to vibration and wide temperature variations would be of special value. **PS**



Prototype fiber-optic gyroscope developed by STL packs a 500-yard coil of glass fiber and all optical and electronic components into a slim case less than 4 in. square. Three such units would be stacked to make up a compact three-axis navigation or stabilizer system. The detail view shows solid-state optical components integrated on a single chip.

Pick of the pickups ***—how much truck do you need?***

These hard-working vehicles feature engines with fuel injection, electronic anti-lock braking, top-handling suspensions, and sedan-style interiors. POPULAR SCIENCE stages an instrumented performance showdown between the four newest American pickups.

By **JACK KEEBLER**
Photos by Greg Sharko

How much pickup do most people need? That's what the POPULAR SCIENCE test team asked ourselves before putting this four-

vehicle group together. Few people need a heavyweight pickup with a 400+ cubic-inch V8 engine, dual rear tires, and luxurious velour-lined extended cab. Yet many people need more than a sporty compact pickup with a gutless four-cylinder en-

gine, vestigial bed, and bare-bones cab.

So what we did was take aim at the dead center of the pickup pack. The result is a foursome of the newest work-ready pickups. All were equipped with muscular six-cylinder engines. And all but one featured an automatic



transmission. Representing the full-size field are the new-for-1987 Ford F-150 XL Lariat and 1988 Chevrolet Cheyenne 1500. (The Chevy, available considerably later than the other pickups, was photographed and tested separately.) The Ford and Chevy went up against the mid-size breed, represented by the Jeep Comanche and Dodge Dakota LE.

The O.K. Corral for this pickup shoot-out was a stretch of taxiway at Stewart Air Force Base in Newburgh, N.Y. The weapons for taking the measure of the group were a Lamar fifth wheel, Alge timing lights, about 50 traffic cones, and a hand-held decibel meter.

But keeping in mind that pickups aren't sports cars, we had to find out more about these competitors than a track test could tell us. We wanted to know how the pickups were for cruising and hauling. Thanks to the PS staff—and numerous loads of firewood, lawn equipment, and bargain furni-

ture, we got a real sense of how these beasts of burden perform in the workaday world.

Pickup power

The 4.3-liter Chevrolet V6 is derived from the company's legendary small-block V8. This 90-degree V6 features Vortec high-swirl combustion chambers, which General Motors claims provide better air-fuel mixing, thus allowing higher compression ratios and greater engine efficiency. Although the 4.3 is the smallest engine available in the Chevy, the truck was second only to the hot-rod four-liter Comanche in the acceleration trials. And by adding throttle-body injection to the V6, Chevy engineers have done an absolutely incredible job of removing the plumber's nightmare of pipes and hoses that entangle most modern engine compartments. This hauler's under-hood area looks about as starkly clean as that of a pickup from the early '60s.

Attached to the 4.3 was GM's four-speed automatic transmission. Truckers familiar with last year's 700R-4 and its abrupt shifts will hardly recognize the new unit. The power-train wizards at GM apparently decided to provide truck customers with the same sweet, smooth shifts that GM auto buyers have been enjoying for years. (Chevy also offers four- and five-speed manuals for those who prefer to shift for themselves.)

The Dakota LE was equipped with the optional 3.9-liter V6, which is derived from the company's 318-cubic-inch V8. As a result, the 3.9, like the 4.3-liter engine in the Chevy, is a 90-degree V6. Despite its being the only power plant in this contest with a carburetor, the 3.9 fires up quickly and runs almost silently on even the coolest mornings. Chrysler says that the engine's aluminum intake manifold, with its high heat conductivity, may be largely responsible for the en-

Continued



Load luggers (left to right): Ford F-150, Jeep Comanche, and Dodge Dakota LE pause before testing. Both the F-150 and Comanche feature in-line sixes with fuel injection, and the Ford comes with Kelsey-Hayes anti-lock rear brakes as standard equipment. The Dakota, Chrysler's new entry in the mid-size market, offers an optional V6 and a plush carlike interior with exceptional ride refinement.



Chevrolet's 1988 full-size Cheyenne pickup features a smooth nose, air dam, and mini-headlights for reduced wind resistance.

engine's quick warm-up performance. Though wonderfully smooth, this engine is not particularly powerful—especially in relation to the other sixes in this test. With the fewest horses available, it was no surprise that the Dakota finished dead last in

the acceleration trials. And frankly, we had to wonder about the 5,500-pound tow claim for the 3.9-equipped Dakota.

Although Chrysler offers a five-speed manual, our test truck was equipped with a three-speed auto-

matic. This transmission snipped off quick, clean automotive-style shifts. Furthermore, with the transmission's shift stalk on the column, the cab has comfortable three-across seating.

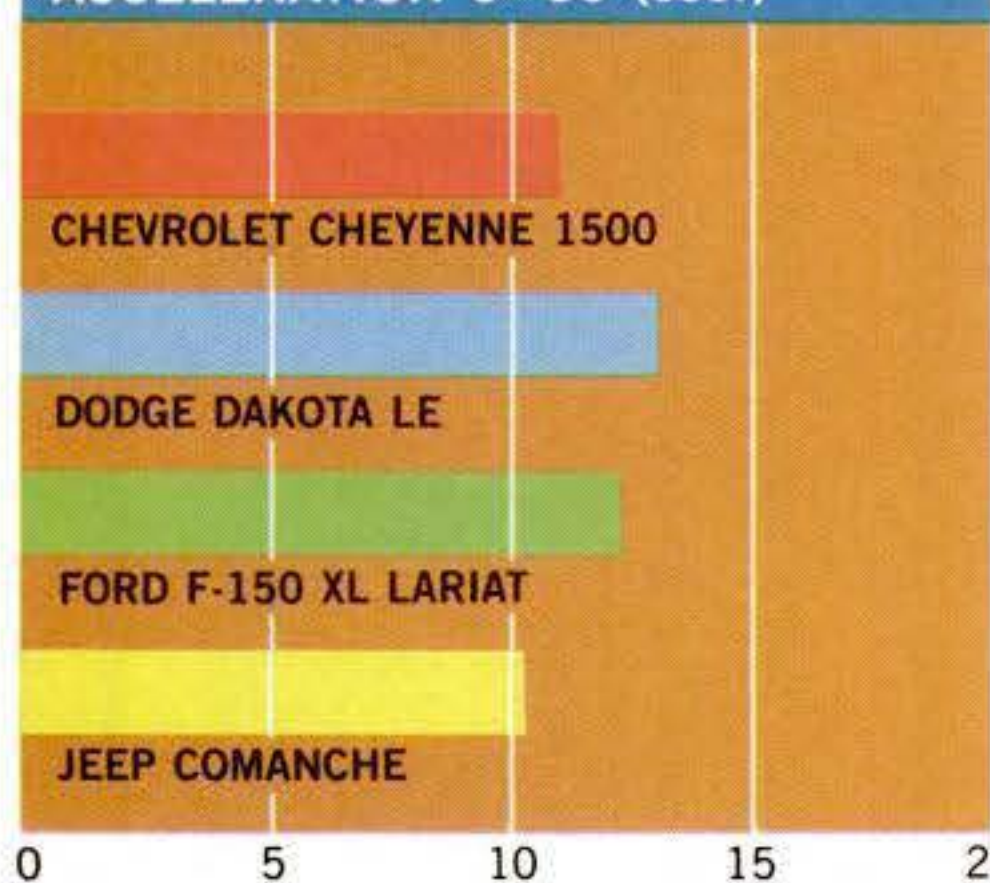
The first thing you notice when you lift the Ford F-150's hood are six long intake-manifold runners. According to Ford engine experts, the long intake tubes fatten the engine's mid-range power band. But to make this tuned-intake system work, each cylinder must be fed with its own private injector. So Ford has adopted a sophisticated multi-point fuel-injection system—similar to that used in expensive sports sedans and the Comanche four-liter engine.

The manifold and injection system help the Ford six generate a stump-pulling 265 pound-feet of torque. This translated into 0-to-60-mph times averaging 12.3 seconds, despite the handicap imposed by the test truck's tall 2.73:1 rear axle ratio.

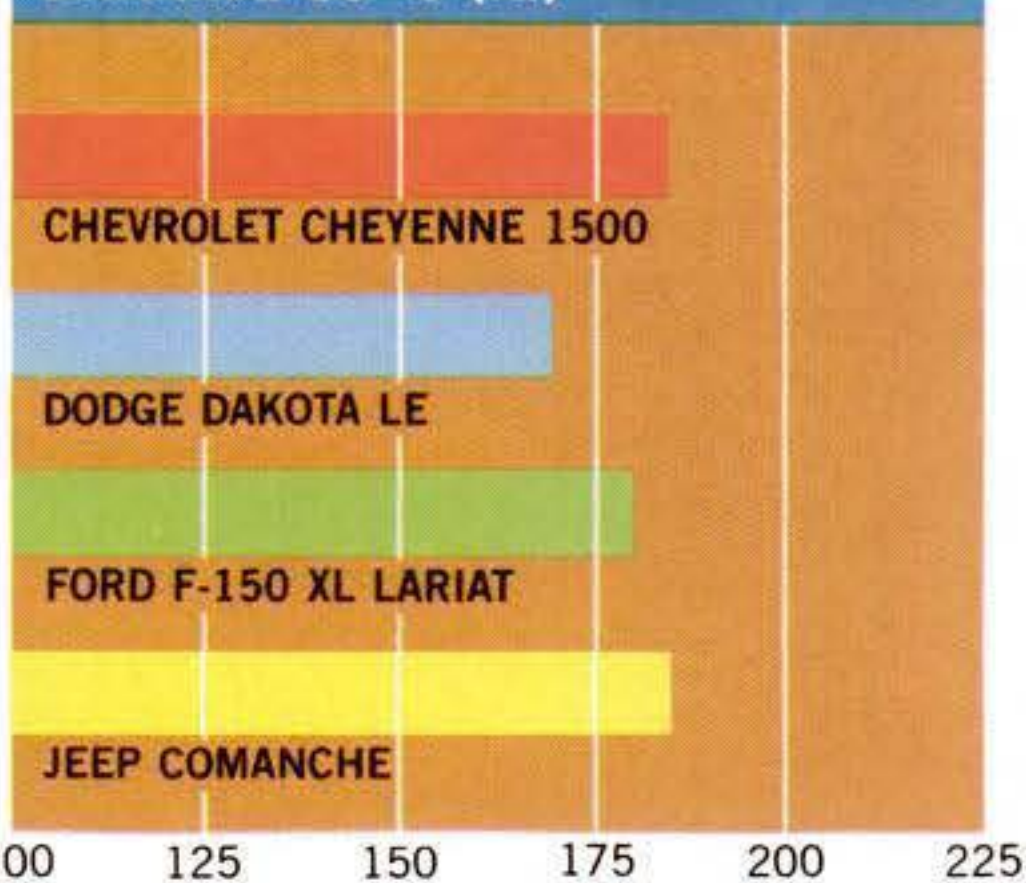
The surge of power available from the Jeep Comanche's new four-liter in-line six gives this truck a totally new personality. In February 1986 we tested a Comanche powered by the GM-built 2.8-liter V6 and a three-speed automatic transmission. That Jeep stumbled to 60 mph in 18.5 lazy seconds. The same vehicle tested this year—this time with a five-speed manual and the new fuel-injection four-liter—lopped better than eight seconds off its 0-to-60 sprint. (The time might have been even quicker, but

Continued

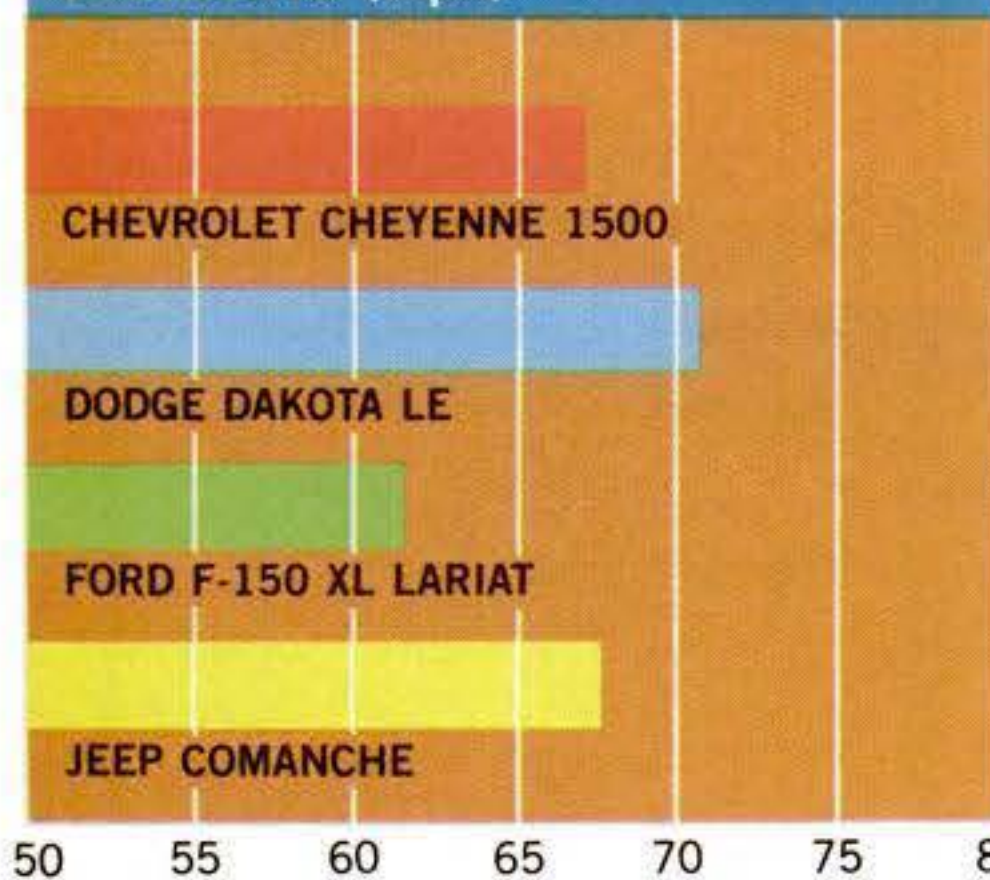
ACCELERATION 0-60 (sec.)



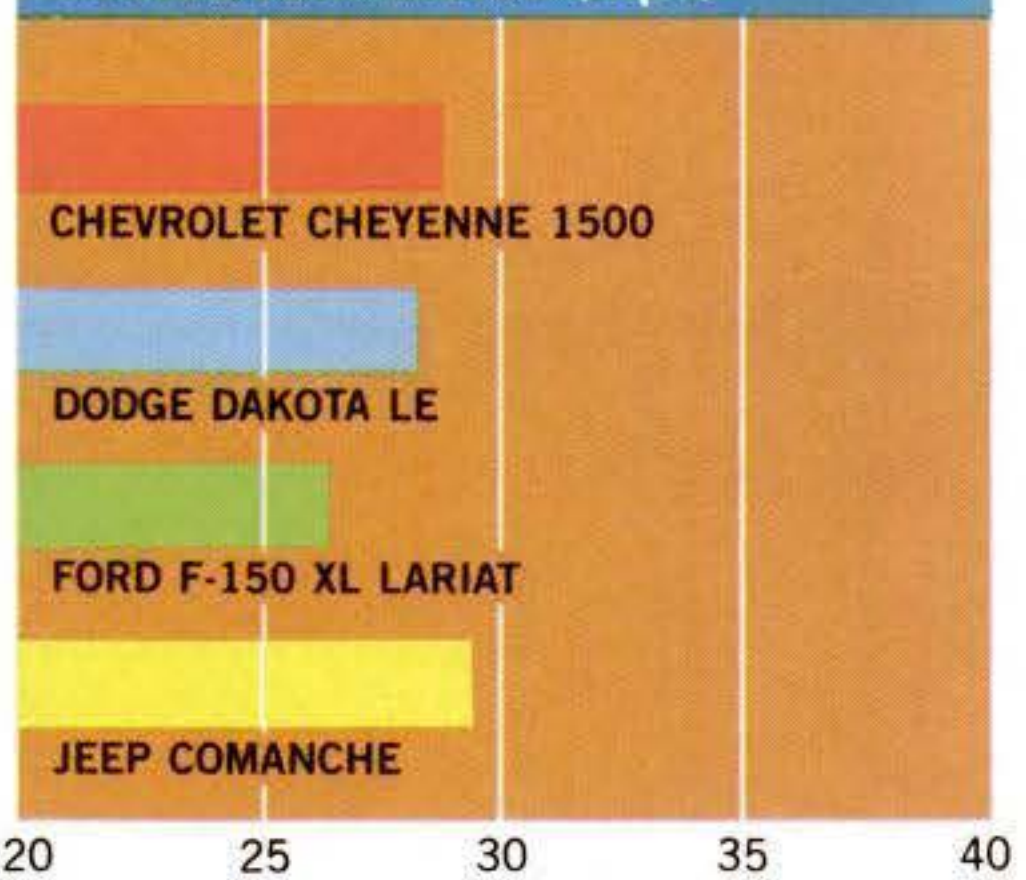
BRAKING 60-0 (ft.)



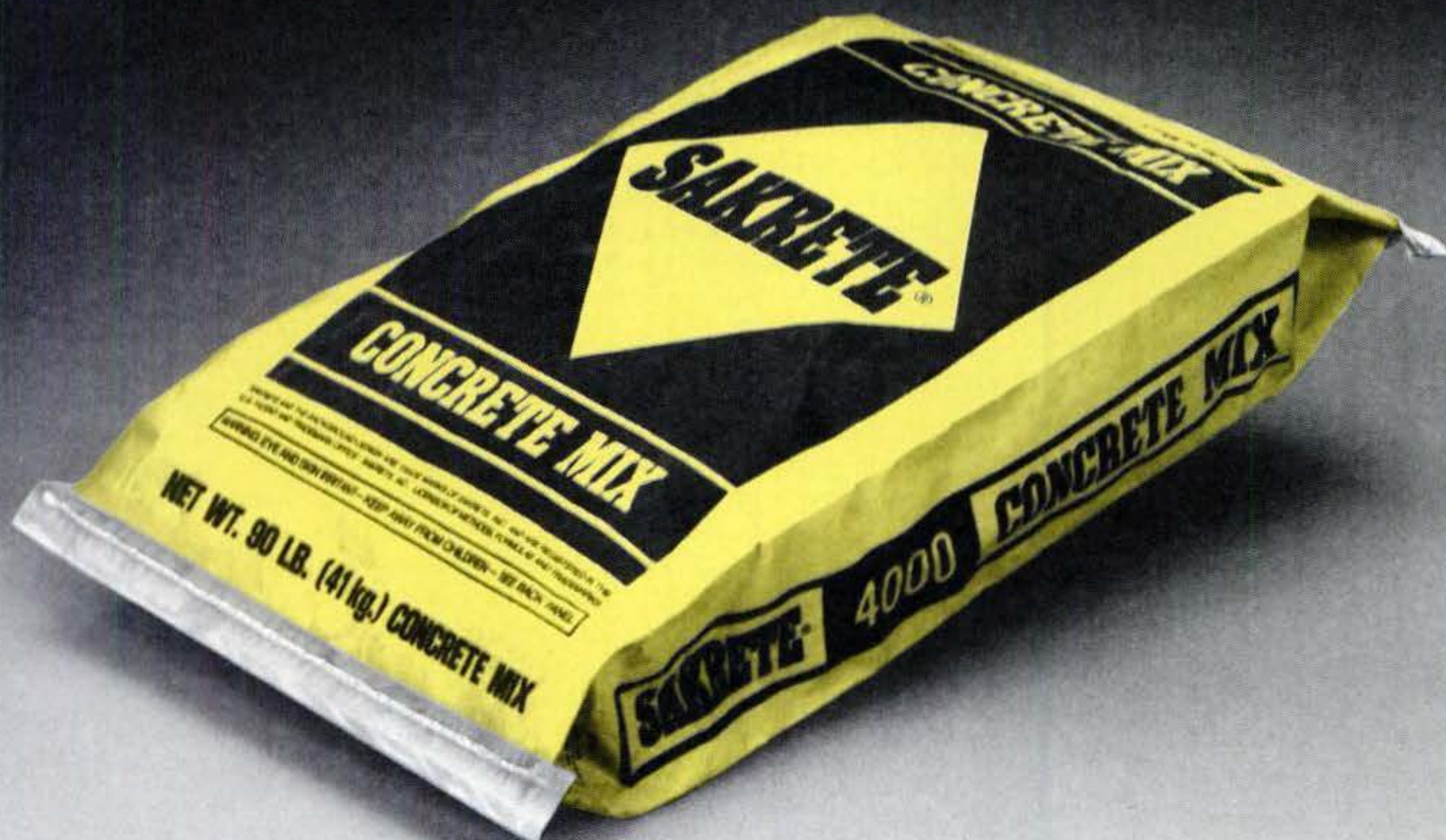
HANDLING (mph)



MANEUVERABILITY (mph)



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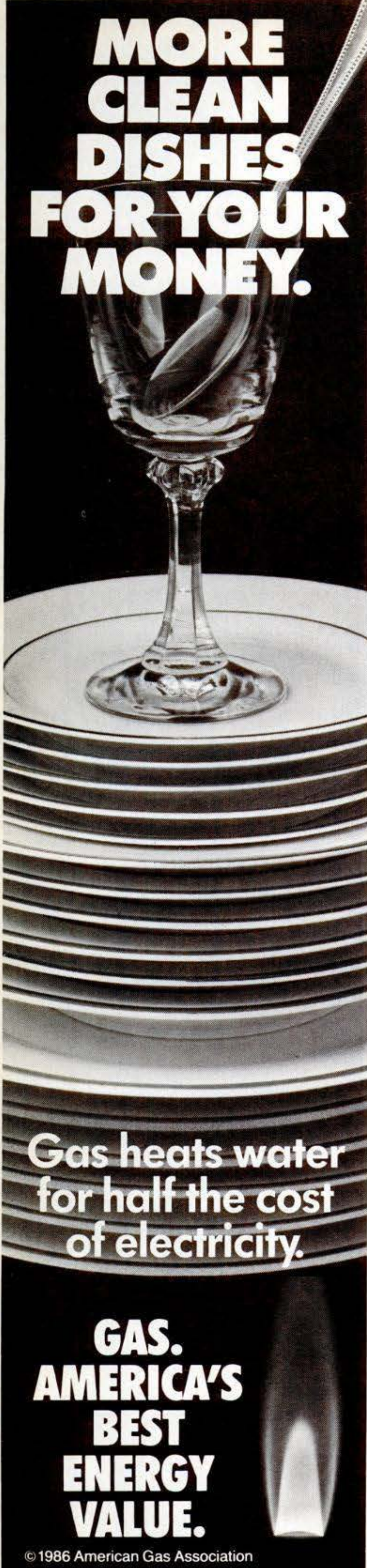
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Pick of the pickups *Continued*

hard acceleration caused severe axle hop, so a conservative launch technique was adopted to preserve the drive line.) Although we requested that the test vehicle be equipped with Jeep's new Aisin-Seki four-speed automatic, supply problems meant that the red Comanche came with the five-speed manual. The five-speed helped make the Comanche (already the smallest, lightest truck in the test) feel like a Porsche compared with the big XL Lariat and Cheyenne. The shift linkage proved to be one of the quickest, lightest actions we've thrown all year—including those in some pretty fancy sports cars. Our only complaint about the transmission was an inordinate amount of gear whine, which seemed to worsen slightly during the month-long test period.

Handling and stopping

Until recently, pickups didn't handle or stop particularly well. Both of these problems were a result of a chassis that was optimized for hauling a load. But with the pickup's greater popularity and increased numbers of first-time buyers, engineers (and company lawyers) realized that something had to be done to tame the pickup.

Judging from the handling and braking tests, truck engineers have made surprising progress in these areas. The soft four-spoke wheel in the Chevy Cheyenne is bolted to a Saginaw steering system that answers wheel inputs quickly, precisely, and lightly. In fact, this full-size truck went around the cones of the high-speed and low-speed handling tests quicker than the Chevy S-10 compact pickup we tested in February 1986. That's significant, considering the 1500 is a foot wider than its baby brother. Stopping the big, new Chevy is a cinch, too. GM now uses an aggressive semimetallc pad on the front brake rotors, and the new Kelsey-Hayes rear-wheel anti-lock system as standard equipment. The result was a short (for a pickup) stopping distance, without a trace of lane wiggle or sideways yaw.

The Dodge Dakota nailed down top honors by a significant margin in two of the most important tests: braking and high-speed handling. Without question, Chrysler has put the accent on automotive-style performance. But that's not to say this pickup is a pretender when it comes to tough jobs. The test truck was fitted with an eight-foot bed, and this mid-size truck has a load range from 1,250 to 2,550 pounds.

Ford has done a wonderful job of freshening the looks of its full-size pickup. But our impression was that

beneath the sheet metal, the truck is largely unchanged—at least as far as handling goes. It took bottom-of-the-class marks in both the high-speed lane-change and low-speed maneuverability tests.

What the Lariat did do impressively well was stop. Only the smaller, lighter Dakota was able to stop shorter. Like the Chevy, the Ford has a standard rear-wheel anti-lock unit that seemed to contribute to its short, stable brake-lane performances.

The Jeep Comanche was top truck in the low-speed maneuverability tests and took a strong second on the high-speed handling grid. Its good showing in the low-speed tests can be attributed to two things: light, quick power steering and a taut suspension. The light steering made negotiating parking lots a snap, and backing up to a loading dock was a one-finger feat of finesse. But though it proved a champ on the smooth test strip, on rough streets the Jeep's high-speed handling was sometimes less impressive. The unloaded back end tended to dance around a great deal, requiring lots of small steering corrections.

The Comanche—like the top-stopping Dakota—comes with a less sophisticated solution to rear-brake lockup than the electronic anti-lock systems on the full-size models. It's called a brake proportioning valve. Mounted on the bed and attached to

View from the driver's seat

How much truck do you need? It depends on what you want to do with it, I guess. For those buying a truck primarily for the image, the Comanche is just about perfect. Yes, it will haul things, like any small truck. But it's the quickest and most maneuverable of the four-some. Best of all, it looks like a Jeep, and if you're buying a pickup for its rugged image, you can't do better than that.

If it's serious hauling you need to do, pick the Cheyenne or Lariat. Both companies subscribe to the building-block principle—you can select from a dizzying variety of engines, transmissions, axles, cabs, and beds until you've assembled the truck of your dreams. The half-ton Chevy feels more nimble than the comparable Ford—if you can call any full-size truck with an eight-foot bed nimble. Otherwise, choosing between the two is strictly a matter of style.

The Dakota seems to offer the best of both worlds. It's quieter and more comfortable than the Jeep, yet noticeably less awkward in traffic than the big Chevy and Ford. If an extended cab were available, I'd pick the Dakota in a moment.

Because it's not, I'd choose the Ford with the in-line six, four-speed manual, extended cab, and short bed. In Bright Canyon Red, thank you. After all, what's the use of all those blocks if you can't build just what you'd like with them?—Tom Wilkinson

the suspension system, it senses the height of the bed in relation to the rear axle, and meters hydraulic pressure to the rear drums depending on load. During our tests, which are done on dry pavement with a light load, the proportioning valves helped both the Jeep and the Dodge score well in stopping distance and stability. We still prefer the electronic anti-lock for slippery pavement, though.

Cab comfort

Many of the pickup field's growing numbers of customers are conquests from passenger sedans. Fully aware of this, truck engineers and stylists are creating cabs with convenience and comfort features similar to those in autos.

Although the Chevrolet 1500 was the only pickup in this contest with rubber floor mats, it was no bare-bones truck. The interior featured a tilt wheel, power windows and door locks, and a four-speaker AM-FM-radio cassette player. All of the interior controls are well positioned and within easy reach. But there is a fly in the interior ointment: poorly designed instruments. Chevrolet uses a new rotating-disc-type dial for the various instrument-panel gauges. Although the gauges are spectacularly clear and easy to read at night, they are virtually indecipherable in bright sunlight—of which there is an abundance, thanks to the cab's generous glass area. Ambient light also washed out the vacuum fluorescent displays for the radio and air conditioner.

On the plus side, this big pickup has a terrific ride. Engineers say that the extra-long leaf springs used in the rear result in lower stress for longer spring life and allow designers to better tune the suspension. Considering that the Cheyenne had a 1,600-pound-plus load capacity, its smooth-when-empty ride becomes an impressive engineering feat. Finally, the long, wide bench and large cab provided the roomy seating typical of a full-size pickup truck.

The Dakota's interior and ride not only set high standards for trucks, but passenger-sedan designers should take note, as well. Night or day, the bright, sharp instrumentation was a snap to read. The A/C, ventilation, and heater controls were simple to use and did an outstanding job of quietly and precisely controlling the cabin temperature. And finally, though I usually dislike plastic wood on instrument panels, I found the subdued test-tube timber in the Dakota's cab tolerable—if not quite attractive.

I'm sure that many auto companies

Continued

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POPULAR SCIENCE TEST RESULTS

TEST RESULTS	Chevrolet Cheyenne 1500	Dodge Dakota LE	Ford F-150 XL Lariat	Jeep Comanche
Acceleration (sec.)				
0-30 mph	3.4	3.9	3.8	3.3
0-60 mph	11.1	13.1	12.3	10.3
Brake test, 60-0 mph				
Stopping distance (ft.)	184	174	180	185
Pedal pressure, cold (lbs.)				
(0.5-G stop)	20	8	12	20
Pedal pressure, hot (lbs.)				
(0.5-G stop)	15	11	14	26
Handling test (mph)	67.4	70.9	61.7	67.9
Maneuverability test (mph)	28.9	28.3	26.5	29.4
Interior noise (dBA)				
At idle	51	46	48	49
At 60 mph	72	69	68	72
EPA FUEL MILEAGE (mpg)				
Highway	22	21	18	23
City	17	18	16	18

Dimensions and specs

DIMENSIONS (inches)				
Wheelbase	131.5	124.0	133.0	113.0
Overall length	194.1	185.9	210.2	179.2
Overall width	76.7	68.4	79.1	71.7
Overall height	70.4	64.2	69.8	63.7
SPECIFICATIONS (as tested)				
Engine type	V6	V6	In-line 6	In-line 6
Displacement (cu. in./liters)	262/4.3	239/3.9	300/4.9	242/4.0
Compression ratio	9.3:1	9.2:1	8.8:1	9.2:1
Induction	EFI	2-bbl.	EFI	EFI
Net horsepower @ rpm	160 @ 4,000	125 @ 4,000	145 @ 3,400	173 @ 4,500
Net torque (lb.-ft.) @ rpm	235 @ 2,400	195 @ 2,000	265 @ 2,000	220 @ 2,500
Transmission	4-speed automatic	3-speed automatic	3-speed automatic	5-speed manual
Final drive ratio	3.08	3.55	2.73	3.08
Steering	Power, recirculating ball	Power, rack and pinion	Power, recirculating ball	Power, recirculating ball
Turn diameter (ft.)	n.a.*	39.8	39.2	41.3
Front suspension	Short and long arm with coil springs	Short and long arm with coil springs	Twin I-beam with coil springs	Live axle with leading links and coil springs
Rear suspension	Live axle with multi-leaf spring	Live axle with multi-leaf spring	Live axle with two-stage leaf springs	Live axle with multi-leaf spring
Brakes	Disc-drum	Disc-drum	Disc-drum	Disc-drum
Curb weight (lbs.)	3,755	3,163	3,750	3,040
F/R weight distribution (%)	58/42	60/40	61/39	62/38
Fuel tank (gal.)	25.0	22.0	35.5	16.0
Base price	\$9,531	\$7,764	\$9,693	\$7,860
Price as tested	\$13,844 ¹	\$12,288 ²	\$12,993 ³	\$12,795 ⁴

* Not available at press time

Major options: ¹A/C \$781, four-speed automatic \$735, AM-FM four-speaker cassette \$454, operating convenience package \$344, chrome rear bumper \$229, deluxe front appearance \$145, engine oil cooler \$126, tilt wheel \$121; ²LE decor package \$1,098, A/C \$781, three-speed automatic \$565, 3.9-liter V6 \$396, power steering \$275, aluminum-alloy wheels \$268, GVW package \$229, chrome step bumper \$181, cloth-and-vinyl trim bench \$170, P215/75R-15 tires \$165; ³preferred equipment package \$2,888, automatic transmission \$601, styled steel wheels \$205, handling package \$132; ⁴A/C \$820, Pioneer package \$699, four-liter engine \$512, all-terrain tires \$352, power steering \$290, trac-lok differential \$279, AM-FM stereo radio \$187, chrome rear-step bumper \$186, light group \$152, protection group \$132, tilt steering \$124, sliding rear window \$117, extra-quiet insulation \$104, conventional spare \$102

Parts and service

PART PRICES (manufacturers' suggested retail)				
Brake pads, front	n.a.*	\$ 47	\$ 32	\$ 60
Brake pads/linings, rear	n.a.	51	68	34
Front shock/strut insert	n.a.	17	25	30
Alternator	\$134	129	265	89
Fuel pump	54	35	35	68
Ignition module	51	110	69	57
Grille	82	79	86	38
Front bumper	175	135	144	102
Windshield	465	213	n.a.	320
Taillight lens	23	41	41	26

* Not available at press time

PS serviceability ratings

Checking oil level	5	5	5	5
Checking coolant level	5	5	5	5
Adding oil	4	5	5	5
Changing oil filter	3	3	4	4
Changing spark plugs	4	4	4	4
Changing belts	5	3	3	3
Changing radiator hoses	4	3	4	3
Changing heater hoses	4	3	4	3
Checking fuses	4	3	3	3
Spare-tire access	3	2	3	3

(Ease of service: 5 = excellent, 1 = poor)

wish their passenger sedans rode as smoothly and handled as precisely as this load lugger. Chrysler chassis experts say the coil springs on the front axle are computer-selected to enhance the ride quality; but in the rear the Dakota features the same live axle and leaf springs as the rest of the pickup pack. Obviously, careful attention to a truck's front suspension plays a big part in achieving a smooth ride and top handling.

Although the long climb to the Ford F-150's bench tends to drive home the point that you're going for a ride in a full-size pickup, the interior has received the same slick styling attention as that of the Taurus sedan. Once you're seated, the interior feels strongly automotive, with clean easy-to-read instruments and well-located controls. The only exception to this ergonomic excellence is the long reach to the radio, air conditioner, and heater controls.

When driven smoothly, the new Ford Lariat shows a great deal of ride refinement. But as the rather poor showing in the handling tests suggest, once you start pushing harder, the Ford starts to feel vague and unsettled, just like earlier versions of the F-series truck. And I was surprised to find the price list included an extra \$132 for a handling package. How would the truck have fared without the extra-cost handling option?

After several weeks with the Comanche, I appreciated its neat, convenient interior and comfortable seating for two. Like those in the Dakota, the Comanche's instruments are easy to read, and the controls are located so the driver never has to lean away from the backrest to adjust the temperature or select a radio station. Though small compared with those of the Chevy and Ford, Comanche's cab has lots of thoughtful storage space for small items, with map pockets in the doors and change holders cast into the center console. But only in an emergency would we suggest three-up riding in this vehicle's cab. Our Jeep's floor-mount five-speed and console used up all the leg room a center-seated passenger would need.

Author's pick

The best light-duty pickup in this test was obviously the Dakota LE. It was top dog in all of the important performance areas, except acceleration. And considering the civilized ride and interior in the Dodge, it makes a strong case for itself. But if a pickup is going to see particularly hard service with lots of rough terrain, trailer towing, and hauling, the Chevy would be my choice.

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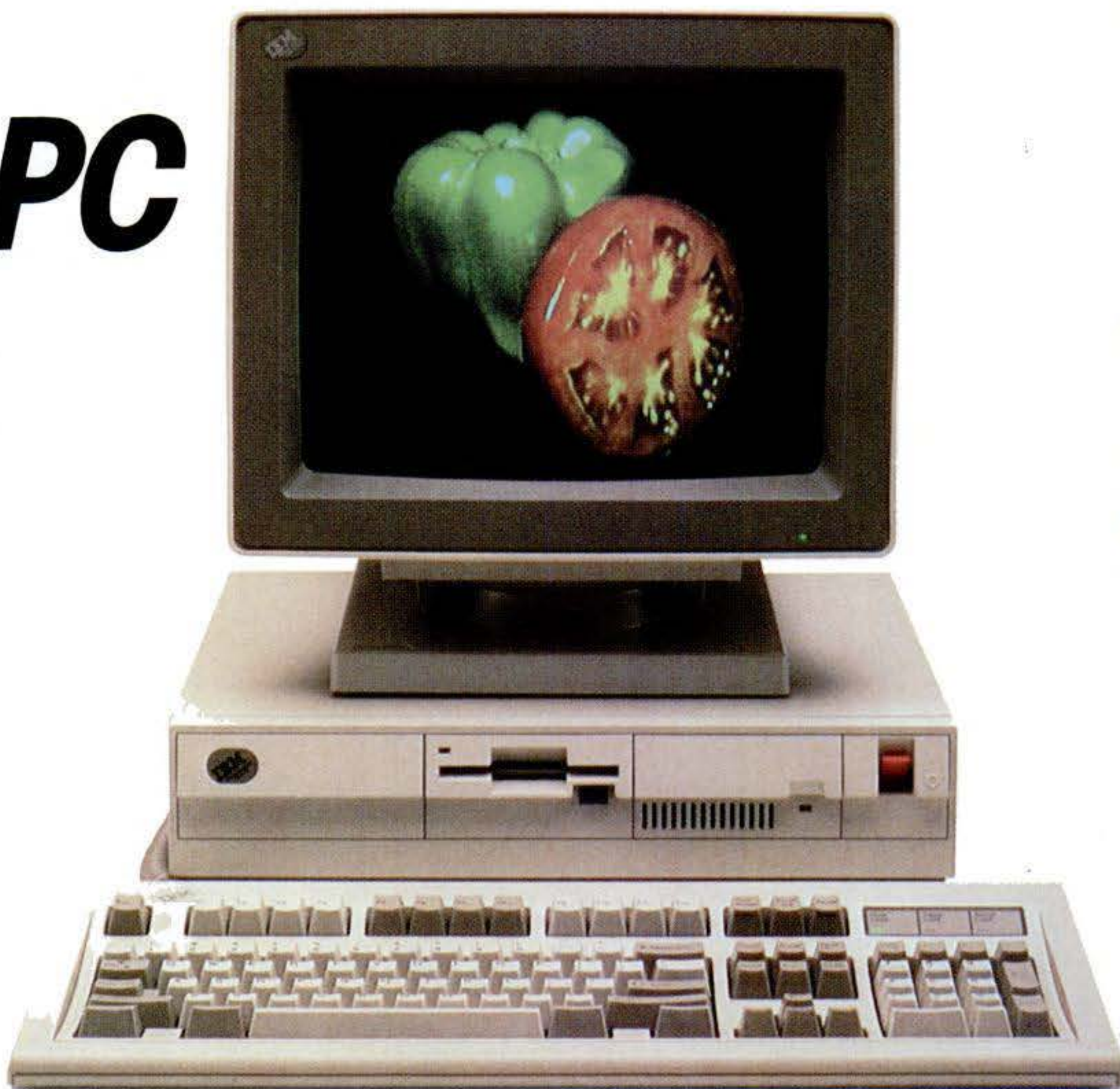
Motorcraft from Ford
EXCEEDS THE NEED

SUPER PC

By WILLIAM J. HAWKINS

If the auto industry had advanced this fast," said a smiling Edward Lucente of IBM Corp.'s Information Systems Group, "today we'd have cars that go from zero to sixty in three seconds, circle Earth ten times on a tank of gas, and cost half as much as they did six years ago."

Lucente's remark, beamed via satellite from Miami to over 20,000 dealers and customers, emphasized the enormous advancements in cost, speed, and capability between IBM's original PC launched in 1981 and the company's newest crop of personal computers, called the IBM Personal System/2. Very-large-scale-integration (VLSI) circuitry, faster microprocessors, a new floppy-disk standard, more memory, a new internal data bus to control hardware, and two new software operating systems are built into four new models that IBM hopes will



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Comparisons based on king-size version of products shown and "tar" levels from Feb. '85 FTC Report or by FTC method.

stave off its competition. Are the IBM PS/2 machines a new breed of super PCs? At present, the jury is still out.

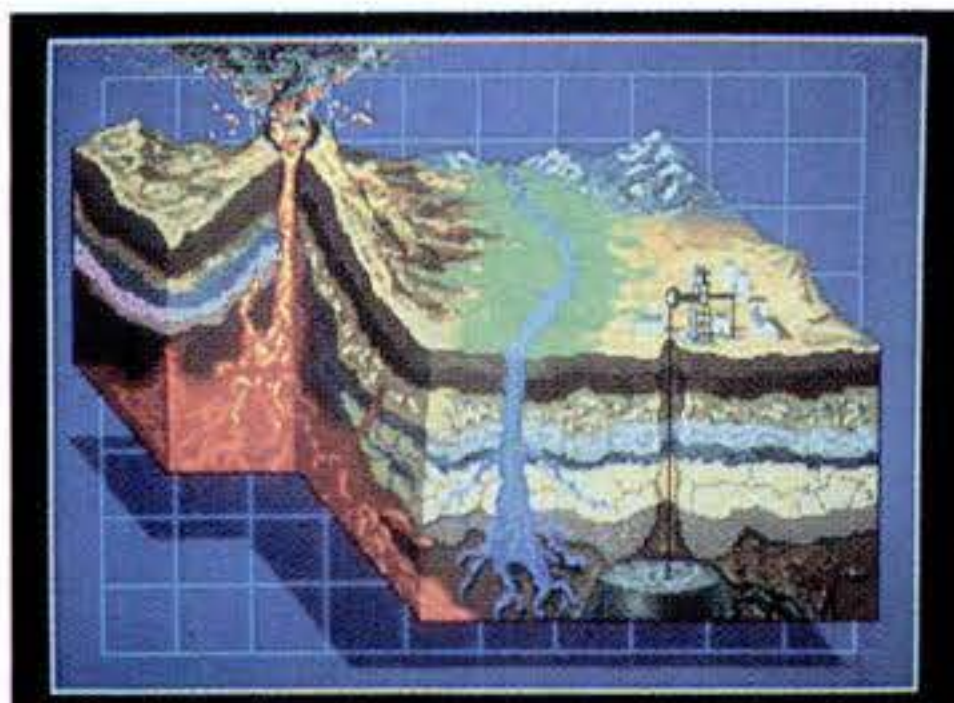
At the company's New York headquarters I watched Edward Kfoury, vice president for the Development Entry Systems Division, wave a book-size PC plug-in circuit board in the air and point to a dime-size gold dot inside the company's new model 30 computer. "This board is now right there," he said.

The gold VLSI chips replace the costly and space-wasting plug-in boards required in earlier PC models for graphics, communications devices, disk control, and mouse controls. Used in the model 30, IBM's new low-end model that's closest to the original PC, no add-on boards are needed for operation. That makes the unit more reliable and competitive: The \$1,695 version includes 640 kilobytes of memory and an 8-MHz 8086 microprocessor to make the computer twice as fast as its older but upscale XT cousin.

Despite the differences inside the machine, the two slots for software disks told of another major change: Say goodbye to 5.25-inch disks.

"We've standardized on the 3.5-inch diskette as the storage media for our

new product line," says IBM vice president William Lowe. "It offers up to 1.44 megabytes on our machines." Although model 30 has two 740K disk drives, the 1.44M versions are included in IBM's other three models, the 50, 60, and 80.



High-resolution color graphics or 16 shades of gray can be displayed.

The \$3,595 desk-top model 50 and \$5,295 floor-standing model 60 use Intel Corp.'s 80286 microprocessor and come with 1M of memory (expandable to 7M or 15M depending on the model). A 20M, 44M, or 70M internal hard disk is available. The 80286 is used in IBM's AT, as well as in many of the newer clones, but soft-

ware runs up to twice as fast in the new machines. Reason: a new 16- and 32-bit bus structure—the circuitry within the computer that shifts data from one place to another—called a Micro Channel.

"The AT handles hardware transactions essentially one at a time," says Lowe. "Our new Micro Channel architecture is, in essence, a multiple-lane highway." The new bus in these models makes all present PC add-on boards obsolete, but IBM is supplying board makers with the details needed to make compatible products.

The higher speed lets the computers control much denser graphics, too. Combined with one of the new high-scan-rate monitors, resolutions of 640 by 480 dots can be displayed. And up to 256 colors, from a palette of 256,000, can be shown at one time.

The new top-of-the-line IBM computer is the \$11,000 model 80. Using Intel's 32-bit 80386 microprocessor, it controls up to a whopping 16M of memory, and it executes instructions over three times faster than the AT. "This puts the power of a System 370 [a main-frame computer that fills a room] under your desk," says Lowe.

Continued

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Super PC *Continued*

A main-frame computer at your feet? Has IBM created the ultimate line of PCs? The answer is varied.

IBM's low-end model 30 is fast, complete, and competitive, but it's not alone. For example, Zenith Electronics Corp. switched to 3.5-inch drives some time ago, and Tandy Corp. has several small desk-top units that include many of the board functions of the VLSI chips, but for less money than the cost of a model 30. "IBM hasn't hurt us at all," says Ed Juge, director of market planning for Tandy.

The Micro Channel bus gives IBM an edge over other more elaborate computers that now use the 80286 or 80386 microprocessor. Presumably, the multi-lane approach will significantly improve the IBM over the competition when future multi-user and concurrent programs are used. It will be some time—up to a year, say the experts—before the new bus could be incorporated in other machines. "It's not good for the clone makers," says industry watcher Esther Dyson, "but they don't expect life to be easy."

The real excitement in power and performance won't be seen for a while, because the software lags far behind this new generation of hardware. At the moment, all the machines use PC-DOS 3.3, a new version of the disk-operating system that lets them use much of the present IBM PC software. However, another operating system, called OS/2 and developed by Microsoft Corp., is expected to be available in the future.

The OS/2 system is designed to take advantage of the extended speed and capabilities of the 80286 and, in particular, the newer 80386 microprocessors. Also, because OS/2 will include a version of Microsoft's Windows operating system, it will be easier to use. Icons and multi-screen displays will give it a Macintosh look and feel, and will eliminate the hard-to-remember PC-DOS commands.

Somebody mention Mac? Those changes could pit the high-end IBMs more solidly against the new Mac II from Apple Computer ["Mega Mac," May]. Speed (16 MHz), power (32-bit operation), advanced graphics, and megabytes of memory make the computers similar in hardware qualities, which will force the two companies to compete with an array of new high-speed super-smart software.

For now, super software for these super PCs is yet to come, but the groundwork certainly seems to be in place. "This isn't just a new addition to the IBM family of products," says Lowe, "but a whole new platform on which to build the future of personal computing."

PS

"Say, Smokey—"

A clinic on cars by Smokey Yunick, America's most famous mechanic

Water on the axle

I have a 1984 Chevrolet Fleetside pickup, which I purchased new. At 16,198 miles (eight months after the warranty expired), I had it checked because the rear axle was making noise. Water was found in the axle housing, enough to have completely broken down the lubricant. The axles were completely rusty, and the ring and pinion gears, bearings, and seals needed replacement. This cost \$621.40. I would like to know what caused this. The dealer's service manager says that sometimes the rear axle just gets hot and pulls water in through the seals. The vehicle has not been in deep water, only in rain on city streets and highways.

Frank E. Mangus, Durango, Colo.

That quantity of water didn't get in there all by itself; your truck's axle had to be submerged in it, either before or after you bought it. A small amount of moisture might leak past the seals under normal conditions, but it would also evaporate and leave through the axle vent after driving the truck long enough to heat up the oil.

Running a red light

I have a 1982 Volkswagen Vanagon diesel that has gone 76,000 miles. The oil-pressure light switches on at idle after as little as 10 minutes of driving at 55 mph. The light goes off if I increase engine speed slightly above idle. The oil-pressure light doesn't go on under any other conditions. I am using 10W-40 oil. The oil-pressure sensor has been replaced.

Zach Kaplan, Alameda, Calif.

Temporarily install a dial-type oil-pressure gauge in the car. You should see 10 pounds of oil pressure for every 1,000 rpm of engine speed when the engine is fully warmed up, as it would be after 10 or 15 miles on the highway. If the pressure is too low, check the condition of the oil pump and pressure-control valve. If they are OK, look for worn or damaged bearings. This advice applies to any four-cycle engine.

Hot day, no start

My 1982 Oldsmobile Omega with the 2.5-liter four has a single-nozzle fuel-

injection system. On a hot day when the engine is warmed up, it is almost impossible to start. If I raise the hood and wait about 10 minutes, it will finally start. I think the problem is vapor lock. The dealer won't say what it is.

C. L. Stringer, Anderson, Ind.

The hot-starting trouble is probably caused by too-hot fuel. Throttle-body fuel-injection (TBI) systems like the one in your car are pretty fussy about overheating. The gasket under the TBI unit is also an important item; make sure you have the latest version of this gasket installed on your system. Check whether the temperature control on the air cleaner is working properly. Finally, if either the air or water-temperature sensors are sour, they can send the computer bad dope on how much fuel to give the engine.

No-start diesel

I have a 1982 Chevrolet Caprice 5.7-liter diesel with 125,000 miles on it. When the engine is cold, the car starts readily. Once the engine is hot, if it is stopped for 30 to 60 minutes, I can't get it started again unless I let it sit for two to four hours. The dealer has replaced the starter, batteries, and fuel filter. This hasn't helped, and the problem is occurring more frequently.

Anders C. Hellstrom
Virginia Beach, Va.

Assuming that your starter motor is cranking the engine at the required speed, here's something else you can try: The next time you expect this problem might occur, remove the fuel filler cap. Leave the cap off until you return for a restart. If the car starts all right, put the fuel cap back on and start looking for the reason the fuel tank isn't venting properly.

Serious hill climbing

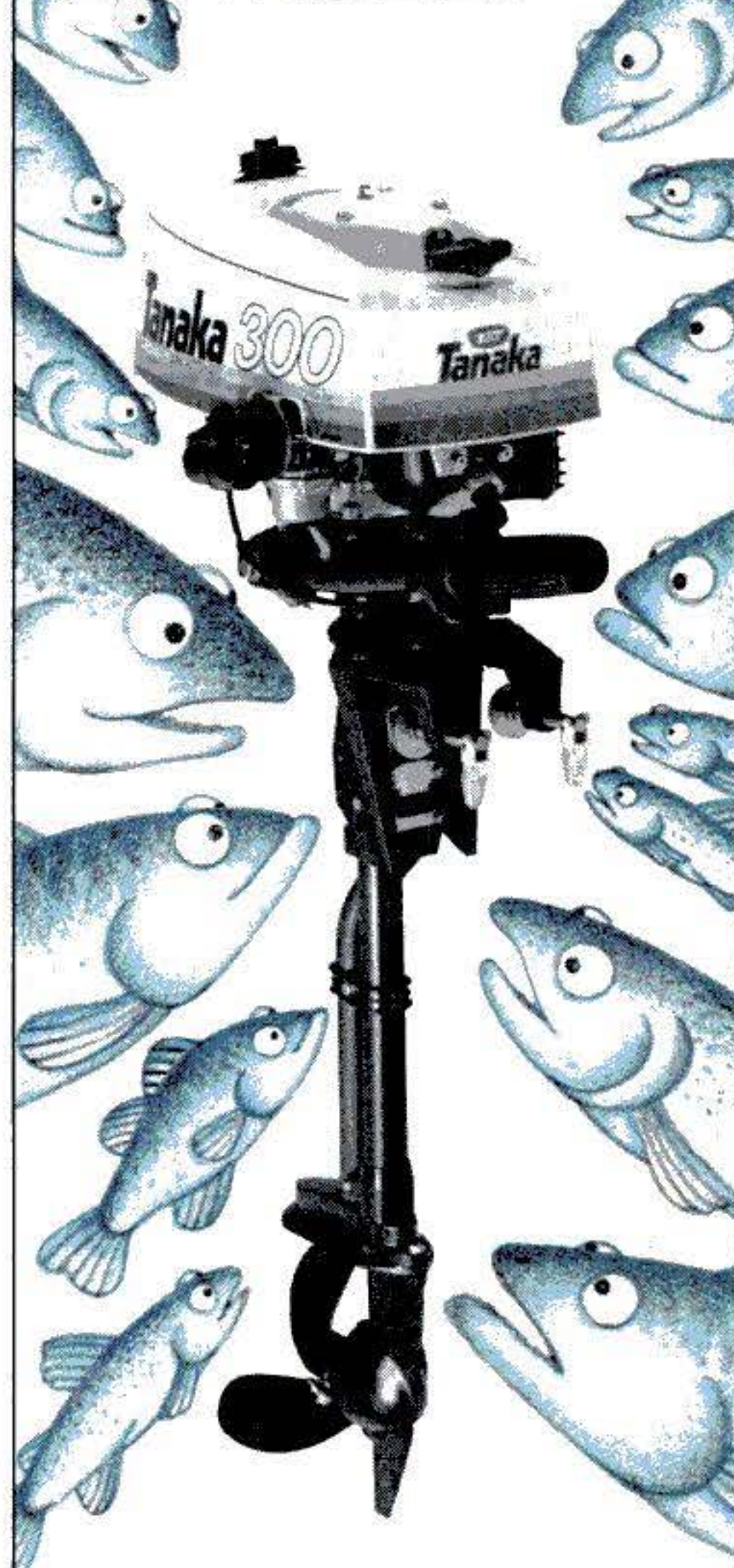
I would like to drive my 1982 Chrysler LeBaron with the 2.6-liter Mitsubishi engine from sea level up to 14,500 feet in altitude at Pike's Peak in Colorado. What changes must be made in ignition timing and carburetion?

John F. Stephenson, Middlebury, Vt.

Don't change anything. Use the highest octane fuel you can find, and keep

Continued

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Do you dream about a lightweight gas outboard that can troll all day at a 1/4 MPH, fine tune speed to current conditions, hold over a good spot, and maneuver in tight spots without spooking fish — all **without fouling or stalling**? Your dream just came true, and for about **half** the cost of most small outboards.

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"Say, Smokey—" *Continued*

your eye on the water-temperature gauge as you go up the mountain. Just don't let it get too hot. The high-octane fuel is important to help the engine resist detonation at the higher cylinder-head temperatures it will develop running heavily loaded at the wide throttle openings it takes to get up the big hill.

That tapping noise

I have a 1982 Chevrolet Celebrity V6 with automatic transmission and air conditioning. Soon after start-up in cold weather, I hear a tapping noise that seems to come from under the front floor near the catalytic converter. The noise speeds up as engine revs increase, but it is not noticeable at speeds above 10 mph.

L. W. Stewart, Greensboro, N.C.

That's an easy one: There's a service bulletin covering this problem. It seems that the fuel-return hose and valve assembly is the source of the tapping. Check with a Chevy dealer for the fix.

Whining and grinding

I have a 1985 Chrysler LeBaron GTS with a five-speed manual transmission. It has 22,000 miles on it. When the transmission is cold, the car will not shift into second gear without severe grinding. Even when it was new, it had a noticeable whine in second gear and wouldn't downshift into second correctly at any temperature. After I put some miles on it, the problems diminished, but the car still has the cold-shift trouble and some gear whine. The dealer has replaced the synchronizer rings and says everything else looks all right.

Fred Gilman, Chenoa, Ill.

The whine in the gears is easy to explain: The gears are out of spec, and should be replaced. As for the shifting, I suspect that the clutch may not be fully releasing due to a sticky spline or uneven tension at the pressure plate. A dirty or oil-contaminated driven disc can also cause disengagement troubles.

Stalls in driveway

I own a 1985 Buick Century with the 3.8-liter V6 engine with port fuel injection. No matter what the temperature is, when the car is first started for the day and then put in reverse, it

stalls when I back out of my driveway. Then, after being restarted a time or two, the engine runs fine. The dealer says this is a fuel-injection problem that affects all General Motors port fuel-injection cars built during this period.

Jerome F. Fiechtl, Derby, Kan.

The car companies are learning more about fuel injection, and the systems are getting better. But you can't update the system without having computer problems and invalidating the car's EPA emissions certification. Have the injectors removed and cleaned (don't forget the cold-start injector); using chemical cleaners is a hit-or-miss approach that doesn't always work. There's also a possibility that there is a sensor in your engine that's not telling the computer the engine is cold, causing a lean condition.

Sluggish on hot days

I have a 1985 Pontiac 6000 STE with an acceleration problem. When the outside temperature is above 80 degrees and the engine (2.8-liter fuel-injection V6) is warm, its performance is weak at the low end of each gear. Also, after a restart when the car has been sitting awhile, there is a stumble on hard acceleration. When the weather is cooler, the engine performs beautifully. The timing has been checked on a computer analyzer, and is according to spec. The fuel injectors have been replaced twice. Do you have any idea what's wrong?

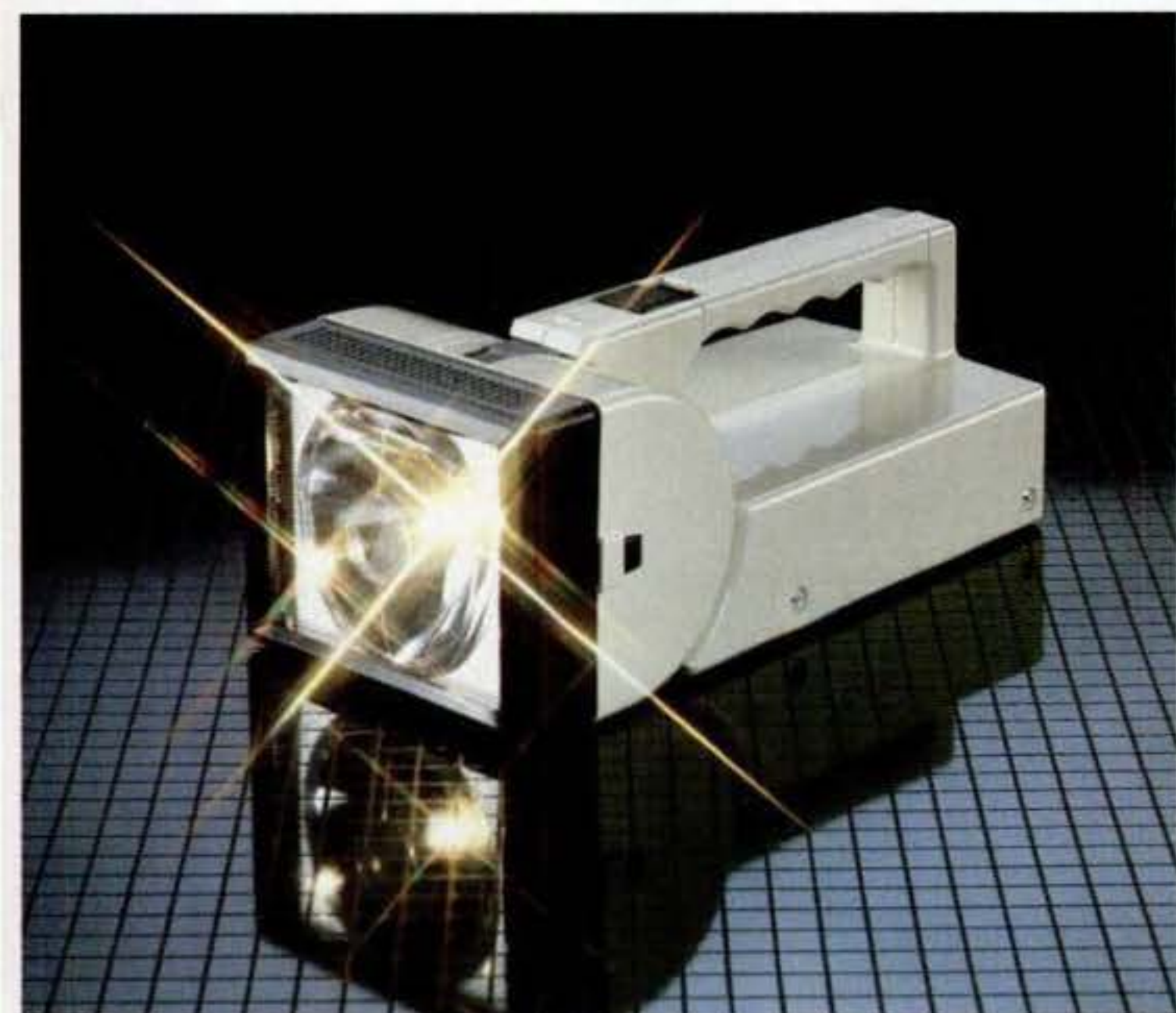
Bob Croft, South Hill, Va.

I suspect that only a Pontiac dealer will have the experience and equipment needed to solve your problem. The symptoms sound to me like a fuel-metering problem, most likely leanness when temperatures are high. The engine computer that controls fuel mixture receives information from several sensors that monitor conditions, including water, air-fuel mixture, and engine temperature. If one of them is bad, the computer will make bad decisions about fuel mixture, ignition timing, and exhaust-gas-recirculation (EGR) control.

Got a car problem? Send it to "Say, Smokey—," POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.

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Father's Day/ Graduation Gift Ideas



First Alert® Ready-Lite™ is the powerful rechargeable light that plugs directly into outlets for recharging. Lasts up to 2½ hours per charge and, when fully charged, can hold power for up to 1 year! Also has KRYPTON bulb, adjustable beam width and swivel head for hands-free use!



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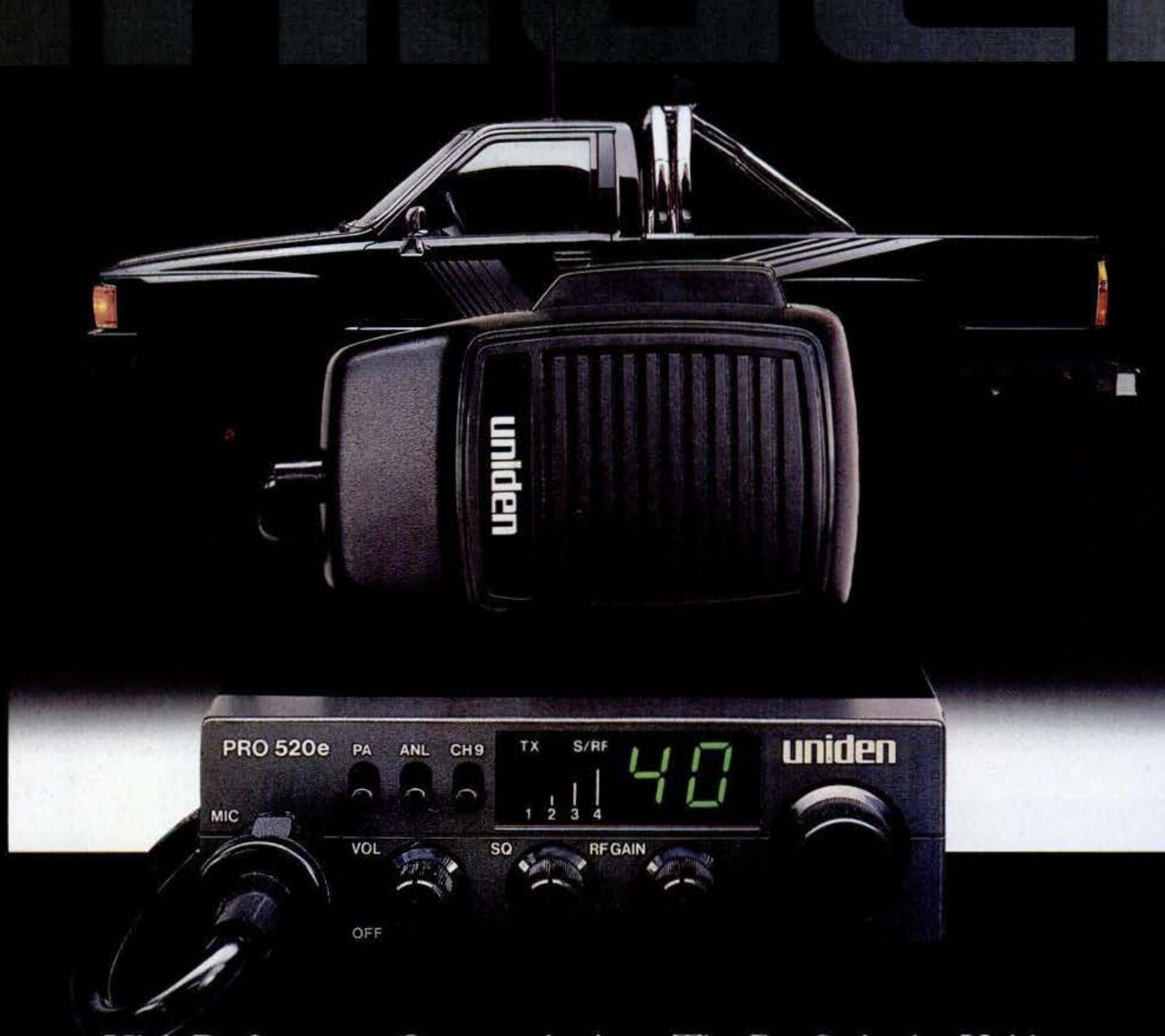
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Father's Day/ Graduation Gift Ideas



New PRO 310e from Uniden. This unique transceiver is a completely self-contained 40 channel CB radio built into a microphone. Comes complete with snap-on battery pack (batteries not incl.) for full CB power whenever you need it. Package includes radio, battery pack, magnetic mount antenna, 16' coaxial cable, carrying case. The superior engineering of the PRO 310e will treat your ears to professional 2-way radio communications as you've never heard it before.

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The Skil Twist® Cordless
Power Screwdriver

SKIL **Twist**®



This shiny red Honda EX650 portable generator is the "strong, silent-type"—the perfect gift for Dad! Equipped with a USDA-qualified spark arrestor and fully-enclosed with an extra large muffler, this 650-watt model features super-quiet operation. For greater durability, Honda's Oil Alert™ system automatically stops the engine before the oil level reaches an unsafe operating level. The EX650 is ideal for camping and other recreational uses.



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If that seems a bit far-fetched, consider: Our automobiles have earned the title twice in the last six years alone. So, why not our riding mower?

After all, both feature powerplants that evolved from innovative Honda engineering. Mid-mounted for optimum maneuverability, the advanced Overhead Valve

engines that drive our riding mowers set the industry standard for fuel and oil efficiency. Like our automobiles, our riding mowers are easy to handle. With Honda's exclusive Mechanical Autoclutch Transmission (MAT™), there's no clutch pedal to operate. You just shift gears and mow. Of course, all Honda products share an impressive reputa-

tion for reliability.

Admittedly, a top speed of 5 mph is slow for a Car-of-the-Year, but a beautifully manicured lawn may help you overlook that. Indeed, you may be inclined to overlook our competition, once you realize that for the price of a riding mower, you can own a Honda.

IT'S A HONDA

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Wash-away plastics

A Swiss polymer-processing firm has developed innovative plastic materials that remain water-resistant during use, but then dissolve away into nontoxic residues after disposal.

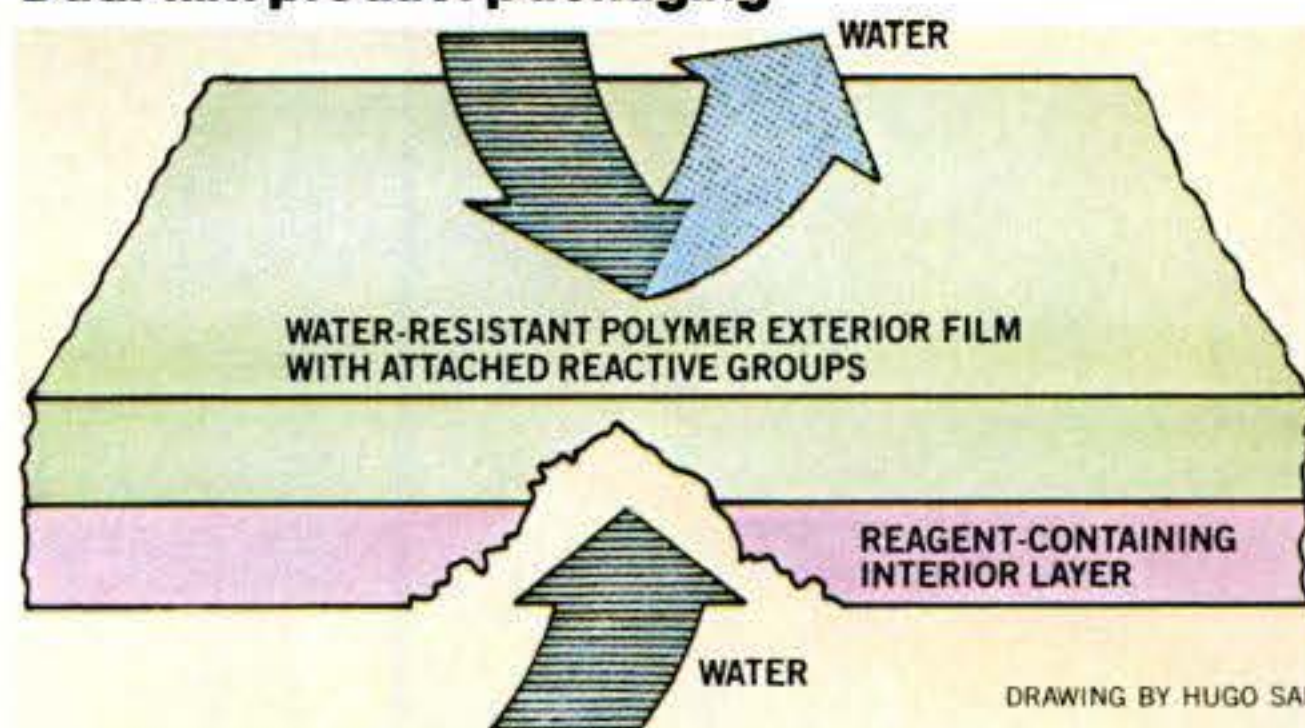
By STEVEN ASHLEY

When tomorrow's archaeologists dig up the long-buried remains of today's civilization, they're going to find a lot of miscellaneous plastic items among the debris. Greatly improved chemical stability has made polymers tough stuff to get rid of. And if you burn it, you get toxic smoke. But now Belland AG, a small polymer-processing company in Solothurn, Switzerland, has developed "intelligent plastics," a group of conventional thermoplastic materials that are engineered to repel water during use, but then to decompose into environmentally safe residues when discarded.

"We can make a water-resistant formulation that changes its mind in the middle of the game... that dissolves on command, so to speak," says Roland Belz, Belland's founder, in a soft German accent as he lifts a pink packet of artificial sweetener from the coffee table. "Let's say you want a package like this," he explains. "Belland can supply you with a plastic pouch whose exterior surface remains impermeable to water for the life of the product." Belz rips open the packet and continues, "But when the consumer opens it, water vapor in the air attacks the inside reaction layer [which contains an acidic or basic reagent] and eventually dissolves the plastic into harmless constituents. The main problem is to tailor the desired physical properties and the speed of the reaction to the particular application."

Many kinds of other applications are possible, Belz

Dual-film product packaging



DRAWING BY HUGO SALHUANA

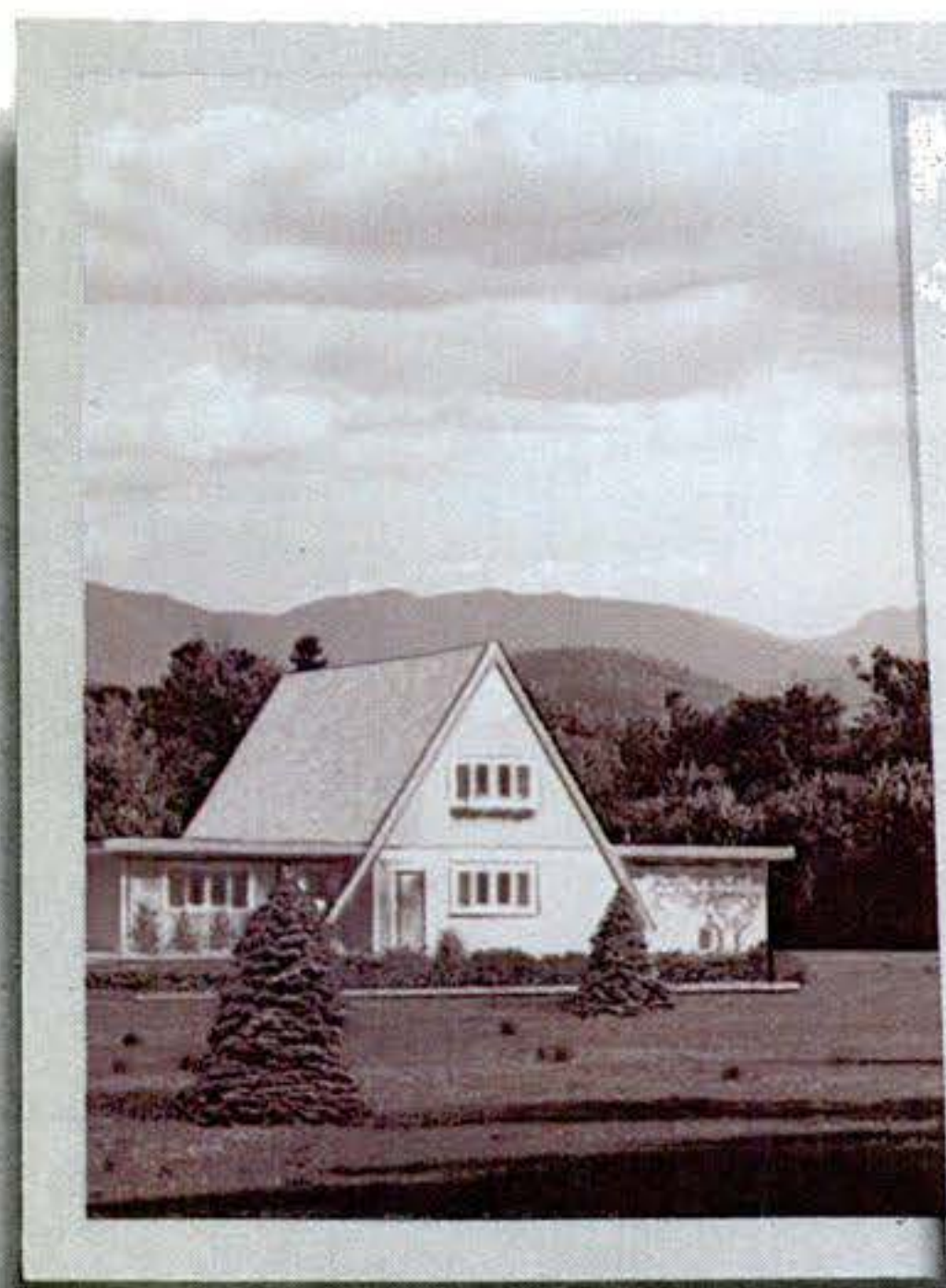
Last year BMW, which owns 25 percent of Belland, tested a new plastic coating as a substitute for the wax it uses to protect the finish of new cars shipped to dealers. Engineers added white pigment to the liquid plastic solution to display the effect, and sprayed it on a blue sedan (top). When the car was doused with water, there was no seepage through the plastic skin. Then a special reagent was added to the water spray; within minutes the car was blue again. BMW engineers say that the new coating is easier to apply than wax and a lot simpler to remove. Another application is water-resistant product packaging (above). Once the packaging film is discarded, water enters the bottom (reaction) layer, mixes with the incorporated reagent, and reacts with the reactive chemical groups attached to the polymer links. The bonds between the reactive groups and the polymer molecules break like perforations between toilet-paper sheets, causing the entire structure to decompose.

claims: temporary shield coatings for new cars being shipped to dealers or for statues under attack by acid rain, disposable plastic bags and containers of all types that disintegrate when thrown out, dissolving labels and adhesives for recycled bottles, protective seed ribbons that

Continued

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To celebrate this silver anniversary of camping, we want to shower you with great camping prizes. Just fill out and send us the entry blank you see here, and you might win one of the following prizes.

Grand Prize

The all new 1988 Sierra with club cab by GMC Truck and a fully-equipped Cirrus 25' Travel Trailer by Yellowstone, Inc., along with unlimited free camping during 1988 (registration fees only) at any KOA Kampground.

First Prize

Jayco® Fold Down Camping Trailer and 25 nights of free camping (registration



fees only) at any KOA Kampground.

Second Prize

25 days free use of a U-Haul® Motorhome, (insurance and gasoline not included) and 25 nights of free camping (registration fees only) at any KOA Kampground.

Third Prize

25 days free use of a U-Haul Camping Trailer, and 25 nights of free camping (registration fees only) at any KOA Kampground.



25 Fourth Prizes

Complete Coleman® Camping Outfits that include a 9' x 12' tent, 4 sleeping bags and air mattresses,

KOA'S 25 YEARS SWEETSTAKES



dining fly (not shown), 48-quart picnic cooler, propane lantern, 2-burner propane stove, and 1-gallon jug, along with 14 nights of free camping (registration fees only) at any KOA Kampground.

25 Fifth Prizes

KOA Camping Kabin Getaway Vacations, consisting of 14 free nights at a KOA Camping Kabin (registration fees only), good at any participating KOA Kampground.



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KOA Value Cards, good for a 10% camping discount (registration fees only) at KOA Kampgrounds (retail value \$4 each).

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1. To enter, handprint your name, address, and zip code on an official entry blank or a plain 3" x 5" piece of paper, or submit a validated receipt from any KOA campsite. Enter as often as you wish, but each entry must be mailed separately to: KOA Silver Anniversary Sweepstakes, P.O. Box 3328, Syosset, NY 11775. All entries must be mailed separately and received by October 31, 1987.
2. Winners will be selected in a random drawing from among all entries received. Drawing will be conducted by National Judging Institute, Inc., an independent judging organization whose decisions are final on all matters relating to this sweepstakes. All prizes will be awarded and winners will be notified by mail. Limit one prize to an individual. In the event the Grand Prize or Second Prize is won by a minor, it will be awarded in the name of a parent or legal guardian. Prizes are nontransferable and no substitutions allowed. Taxes and licensing fees, if any, are the responsibility of the individual winners. Winners may be asked to execute an affidavit of eligibility and release. No responsibility is assumed for lost, misdirected or late mail.
3. Sweepstakes open to residents of the U.S. and Canada (void in Quebec), except employees and their families of Kampgrounds of America, its franchises, affiliates, subsidiaries, and advertising agencies, and Don Jagoda Associates, Inc. This offer is void wherever prohibited, and subject to all federal, state, provincial, and local laws.
4. Winners residing in Canada must successfully answer a skill-testing question as a prerequisite to receiving their prize.
5. For a list of major winners, send a stamped, self-addressed envelope to: KOA Silver Anniversary Winners, P.O. Box 3351, Syosset, NY 11775.

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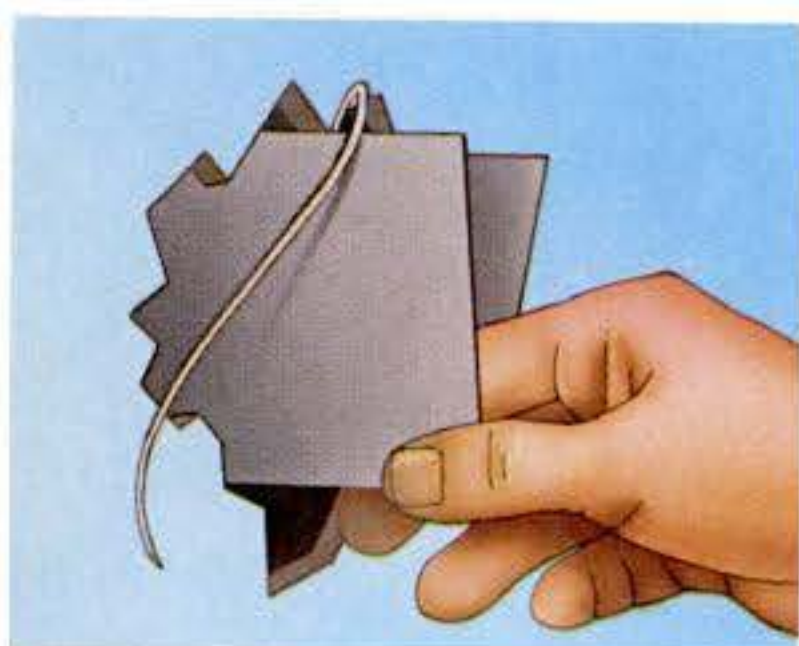
25 years

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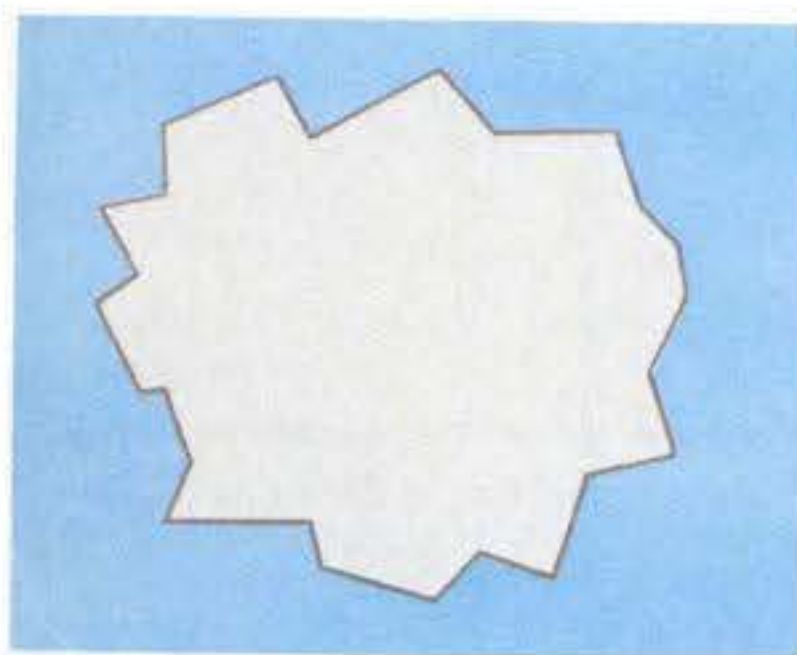
Want to patch a hole like a professional? Learn this card trick!



Patching a large hole is tricky, because ordinary spackling can cave in or shrink up. That's why you need these tricks: Use a piece of cardboard with string through the center, and be sure to use DAP® Fast 'n Final™



Place the card through the hole and pull the string so it's tight against the back of the opening. Now, patch the hole with DAP Fast 'n Final—it's better than ordinary spackling because it won't shrink or crack as it dries.



With Fast 'n Final, one fill and you're finished. Cut the string flush against the wall, and you're ready for painting!

Depend on DAP



Wash-away plastics

Continued

dissolve into ammonia-based fertilizer—even graffiti-resistant coatings for subway cars.

Oddly, the idea arose more than a decade ago from Belz's attempt to solve a common, though rarely mentioned, problem: dirty public restrooms and the necessity of using strange toilets. His interest was not only personal, for Belz knew that a waterproof yet disposable toilet-seat cover would find a large market. A patent search revealed thousands of toilet-seat-cover designs, basically of two types: flushable paper sheets that tear and slide easily; and tough, non-slip, waterproof plastic covers that could clog up plumbing.

Smart plastics?

Despite various polymer chemists' advice that "no plastic is so intelligent," Belz began to search for a material that would combine the advantages of both paper and plastic. With just a modicum of chemistry background, Belz, a trained economist, launched into years of research and finally came up with a rudimentary production system for a polymer material that exhibited some of the desired characteristics. Independent tests at Battelle Memorial Institute in Frankfurt, West Germany, confirmed that he was on the right track. By 1983, Belz had founded Belland.

"At first it was just trial and error," Belz says, "but after some time we started to understand the kinetics of the chemical reactions enough to develop an extensive data base involving hundreds of parameters. At the same time, we came up with a way to manufacture the plastic in a single production sequence with a twin-screw extruder that uses computers to control the chemical reactions, the refining [compounding and blending], as well as any further processing. When a customer comes to us with specific requirements for physical properties," he continues, "we just plug in the numbers, and the data base gives us a starting-off place based on experience that helps us choose the appropriate processing parameters. And we can make the product in many forms: granulates or pellets, films, sheets, tubes, adhesives, as well as water or solvent-containing dispersions."

Belland is planning to license its technology as well as to enter into joint ventures with other companies to develop specific applications. The Swiss firm also has plans to set up shop somewhere in the U.S.

"I tell customers that none of our products are made to last an eternity," Belz says. "That's a total change in thinking for the plastics business." **PS**

Save Gas, Save Engine with 'POLY'

The following introduces one of the most fully tested and credentialed gas saving, friction reducing engine treatments ever to reach the market!

WHAT IS POLY? "Poly" is short for polytetrafluoroethylene (TFE). It is the slipperiest substance known to man (1981 Guinness Book of World Records, p. 188). The PetroLon Corporation, makers of Slick 50, has invented a way to permanently bind this slippery chemical to your engine with one treatment. All you do is add one quart of Slick 50 to your oil during oil and filter change. By reducing engine friction, Slick 50 increases gas mileage and horsepower and reduces engine operating temperature thus causing your oil and engine to last longer. Just as important, it reduces metal wear, defraying costly overhauls.

HOW DO I KNOW THIS ISN'T A FRAUD? Slick 50 has some very impressive credentials. The "Consumers Digest" magazine (March/April 1982, p. 35) states "Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about two or three miles per gallon. . . . Slick 50 does exactly what PetroLon claims it does." Researchers at a **nationally respected research laboratory**, after applying a powerful ultrasonic cleaning process to a Slick 50 treated engine part, were surprised at its permanence. They stated, "We actually expected the PetroLon Slick 50 TFE Resin coating to also be removed, but later found it was still there."

The **Federal Aviation Administration** has fully accepted a similar product- Slick 50 Aircraft Treatment (F.A.R. #33.49). An FAA test simulating 1400 hours of engine use (equivalent to about 70,000 miles on a car) showed almost zero engine wear!

"**Dune Buggies and Hot VW's**" magazine, April 1983, p. 70-71, records the results of their one year testing of Slick 50. "We can indeed say scientifically that Slick 50 does work and that it does reduce engine wear! . . . for the price of one treatment when compared to engine rebuild, we feel you'd be money ahead using Slick 50."

A test done at the **San Diego State University** revealed that, "Slick 50 does increase horsepower and decreases fuel consumption in tests done at the university." The **Space Shuttle Columbia** uses the chemical "poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

Perhaps the most dramatic of all is a



torture-test overseen by the **Automotive Services Council for Pennsylvania** and shown on television station WTVE. Three cars with between 75,000 and 129,000 miles on them were treated with Slick 50. Six months later the oil was drained from each vehicle and the cars were driven without the oil plugs for about a half hour. The water temperature never rose and the engines sustained no apparent damage. There are many more tests available. If you are still skeptical, send \$2.00 to defray printing and postage costs and we will send you additional, more detailed, test information, etc.

HOW DO YOU TREAT AN ENGINE? Very simply. Just before oil and filter change, add engine flush (sent free with each order) to clean out your engine. Let your engine idle for 5 minutes. Then drain your oil, change filter and add the proper amount of oil less one quart. Add one quart Slick 50, drive for 30 minutes, and leave it in the crankcase for 3,000 miles. As the engine operates, the oil carries the "poly" between the parts where it is burnished into the pores of the metal. Once impregnated it is permanent, so **you do it only once**, not each time you change oil. One quart of Slick 50 will treat all standard 4, 6 and 8 cylinder gasoline and diesel engines.

WILL IT WORK WITH MOST OIL? Yes, Slick 50 will work with all petroleum based oils and all synthetics compatible with petroleum based oils.

WHAT ARE THE BENEFITS OF SLICK 50? Your actual benefits in percentages may vary, depending on the kind of driving you do, vehicle condition, etc. By reducing friction,

Slick 50 does all of the following: it **increases gas mileage**. It **increases horsepower** -- small economy cars and large RV's really need this. It makes for **easier starting** (important in cold weather). It **reduces operating temperatures**, thus increasing the lubrication and life of your oil and your engine. Since lubricating lead is being removed from gas and unleaded gas is poor in lubricating qualities, the **extra lubrication of Slick 50 on valve stems and guides is very valuable**. Last, but not least, the drastic reduction in engine wear **defrays or eliminates costly overhauls** which can save you over \$1,000. Slick 50 eliminates the "lubrication starvation" that all cars experience when first started before the oil has a chance to circulate. Up to 90% of the wear on a car can be caused by this lubrication starvation. You receive all of these benefits for **less than the cost of two tanks of gas (\$39.95)**.

WILL SLICK 50 HARM MY ENGINE OR AFFECT MY WARRANTY?

No! Slick 50 is suspended in an excellent grade of petroleum oil which meets or exceeds every manufacturers engine warranty requirements. In addition, this oil carries an API (American Petroleum Institute) service classification SF-CC-CD.

DEALERSHIPS ARE AVAILABLE.

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Clou Liner 3800's garage flips open and gobbles up a subcompact car. A motorized winch hauls the vehicle up the ramps.

RV review

Innovative products have arrived in time for the current camping season. Two king-size motor homes (one fit—and priced—for a monarch), more-powerful compact tow vehicles, new motor-home chassis, and recreational-vehicle accessories highlight this survey.

By JACK KEEBLER

A large motor home may be the ultimate in personal road transportation. Unfortunately, a big RV can be a bear to drive in heavy traffic. So, many motor-home owners tow small cars in which to go exploring. But towing a car is inconvenient and reduces maneuverability.

The \$245,000 Clou Liner 3800 (photo above) offers another option: a garage. Your subcompact car slips into the 38-footer's tail below the master bedroom.

This West German-made rolling hotel suite also comes with a custom teak interior, heated bed with built-in VCR and television, and dual Blaupunkt stereo systems. For the wealthy—and wary—bullet-resistant versions are available.

Tow muscle for compacts

American Motors Corp., Ford Motor Co., and Chevrolet Motors Division are

all packing more power into their compact trucks. This makes small trucks better tow vehicles.

AMC has installed a four-liter fuel-injection-equipped in-line six in its Comanche pickups and Cherokee/Wagoneer sport utility vehicles. This engine bristles with 173 horsepower and 220 pound-feet of torque, providing a respectable 5,000-pound tow capacity.

At Ford, Mike Zevalkink, manager of Bronco II development, confirmed rumors that five-liter V8 versions of Ford's Bronco II and Ranger are cruising the company's proving ground. Currently, those compacts sport a 2.9-liter V6 (140 hp and 170 lb.-ft. of torque) as their top engine option, which provides a 5,600-pound towing capacity.

"We've enjoyed a [towing] lead until recently, and we'd like to regain that lead, but the V8 probably isn't the way to go in the compacts," says Zevalkink. "We're also looking at supercharging

and turbocharging for compacts. These actually may be more promising."

Chevrolet/GMC Truck & Bus Group compact pickups and sport utility vehicles suffer a serious lack of power compared with the rest of the field. But several Chevy truck engineers assured me that this won't be true much longer. The fuel-injection-equipped 160-hp 4.3-liter V6 used in the company's Astro/Safari mini-van and full-size pickup will replace the present 2.8-liter V6 sometime next year. Although the 4.3 enjoys a healthy 35-hp advantage over the 2.8, the real difference is in torque. The smaller V6 twists out 150 lb.-ft. of torque at 2,400 rpm to the 4.3's 230 lb.-ft.

Largest yet

The 1987 Elandan 37RQ (next page, top) is the longest motor home ever manufactured by Winnebago Industries, Inc. A few of the 37-footer's standard features: queen-size bed in the

Continued

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The Winnebago Elاندan 37RQ is the longest motor home the company has ever constructed. Base price of the 37-footer is \$57,393. Note the smoothly sculpted nose, extreme windshield angle, and aerodynamic side-view mirror fairings.

rear bedroom, dual rear wheels, a single-wheel tag (trailing) axle, and power steering. The vehicle has a standard sleeping capacity of five and an optional capacity for six snoozers.

All of this is assembled on a Chevrolet chassis with a 208-inch wheelbase and gross vehicle weight (GVW) rating of 17,000 pounds. Muscle for long grades is provided by a 454-cubic-inch Chevrolet V8. Power is transmitted to the rear wheels via a three-speed automatic. Fuel economy is in the 7- to 9-mpg range.

Chassis chatter

Ford, a longtime chassis supplier to RV makers, is offering an optimized A-class RV chassis, and Deere & Co. is introducing A-class RV chassis for the first time this year.

The Ford-design A-plus van chassis features special smoother-riding shocks, springs, and stabilizer bars specifically tuned for RV customers. Power is provided by a 7.5-liter V8 pumping out a

grade-grinding 245 hp at 4,200 rpm and 385 lb.-ft. of torque at 2,800 rpm. The A-plus chassis has a GVW rating of 11,500 pounds.

According to David W. Tarrant, Ford Division RV sales manager, the A-plus will soon benefit from the new Kelsey-Hayes rear-wheel-only anti-lock braking system. He also tells me that a new Ford chassis with a 16,000-pound GVW capacity is on the way.

Interestingly, Ford will be supplying the 7.5-liter V8 engine and C-6 three-speed automatic transmission for the rival John Deere RV chassis offered with 178-, 190-, 208-, and 228-inch wheelbases. The GVWs of the Deere chassis range from 15,400 to 18,000 pounds. Winnebago is one of the many RV builders now using the new Deere units.

Low profile and cool

RV makers are paying greater attention to vehicle aerodynamics to en-

hance fuel efficiency. Now they're getting some help from a maker of rooftop air conditioners.

The Coleman Co. has engineered a new low-profile rooftop RV cooler called the Super Mach. It's just 9½ inches tall and uses a special horizontal compressor, dual blower wheels, and large wraparound coil to provide 13,500 Btu/h of cooling capacity. The new Coleman unit is priced at approximately \$700.

Tankless RV hot water

A tankless water heater capable of delivering 30 to 60 gallons of 90- to 105-degree-F water per hour—hour after hour—is now available for motor homes. The 110-volt unit, made by Chronomite Laboratories, Inc. (21011 S. Figueroa St., Carson, Calif. 90745), weighs just six pounds and measures 6 by 9 by 2½ inches. Water is heated automatically when the tap is turned on. Price: \$245. PS



AMC's compact sport utility vehicle currently leads the pack in engine muscle for towing with a 173-hp in-line six.

A man and a woman are in a field of tall, dry grass. The man, on the left, is wearing a plaid shirt and is smoking a cigarette. The woman, on the right, is also wearing a plaid shirt and jeans, and is pouring liquid from a silver thermos into a cup. In the background, there is a large haystack and a clear blue sky.

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What's News

The tragic loss of *Challenger* may have had yet another cause, undisclosed until now. A University of Wisconsin professor, William P. Birkemeier, says that undetected wind shear may have placed extra strain on the booster-rocket O-rings now identified as the cause behind the accident, resulting in their failure.

Birkemeier, who has studied high-altitude winds and wind detection for 20 years, points to several pieces of evidence. Videotapes of the flight, for example, show sharp right-angle jogs in the smoke trails left by both the rising rocket and falling wreckage. He has also analyzed satellite photographs of the Cape Canaveral area shot while the shuttle was being launched and found confirming evidence of strong winds. And he got from NASA the data on engine swiveling during the shuttle's brief flight. (The rocket engines swivel to keep the vehicle on course.) The swiveling pattern, he says, is exactly what would be expected if the rocket were knocked off course by shearing winds.

Chief astronaut John Young, commenting on the new finding, said NASA should look into the wind-shear problem and perhaps set up better methods of detecting shear. Otherwise, he said, "we may learn from another sad experience that we have not fixed the complete problem correctly."

Fighting wind shear

Robert Gannon's article on wind shear [March] pointed out that the phenomenon is more common than previously thought, that pilots can sometimes fly out of it if they recognize it soon enough and apply proper corrective measures, and that cockpit instruments to help them recognize it early are on the way. There is progress to report on two fronts. First, Boeing Co. has designed and delivered to the FAA a training program that will teach pilots how to fly through wind shear. McDonnell Douglas Corp. and Lockheed Corp. also contributed to the document, adapting the training procedures to the flight characteristics of their aircraft. A regulation

in the works will require that all airline pilots go through the training.

Second, cockpit instruments to detect wind shear early are being approved for use. The Boeing 737 now has an approved instrument available, as do some models of the 767. The 757 and other 767 models have just been approved, and the 747 will have such an instrument available in 1988.

Looney concrete

What may be the smallest batch of concrete—and the most expensive—has just been made. Workers at Construction Technology Laboratories in Skokie, Ill., made the concrete with 1.4 ounces of soil that NASA brought back from the Moon. They cast a one-inch cube and three small beams three inches long and a fraction of an inch in the other dimensions, then put them through conventional engineering tests.

The conclusion: If we ever want to put a station on the Moon, we can build it of concrete made of lunar materials. Alumina cement can undoubtedly be made by heating Moon rocks, and the soil makes a fine aggregate. The only problem would be water, which does not exist in a free state on the Moon, although it can be obtained by heating ilmenite, a mineral found in some lunar soil, in the presence of hydrogen.

People who think about such things are already beginning to talk about what buildings made of this concrete would be like. First, they would not have to be braced to withstand earthquake shock or wind load. And with gravity at one-sixth Earth value, structural members could be longer. But the building would have to be able to maintain one atmosphere inside, to shield its inhabitants from cosmic rays, and to withstand strikes by micrometeoroids traveling at speeds up to 25 miles per second.

Auto navigation

The ETAK navigational system Herb Shuldiner wrote about in the June 1985 issue is now being tested in 15

National Car Rental System cars in San Francisco. The navigational system, which uses motion sensors to constantly update position on a map displayed on a CRT screen, would be particularly useful for out-of-town drivers who rent cars at airports and don't know the surrounding area too well. National says General Motors Corp. will make the device available as an option on '89 cars; GM says it never discusses future product plans.

Laser sight

POPULAR SCIENCE has been covering developments with that marvelous light source, the laser, since the first one flashed into action at Hughes Research Labs almost 30 years ago. Now, perhaps one of the most astonishing applications so far: Dr. Herbert E. Kaufman, an ophthalmologist at Louisiana State University, New Orleans, is about to try to make nearsighted people see normally by reshaping their corneas with an excimer laser.

The development grows out of a discovery made a few years ago by Dr. R. "Srini" Srinivasan of IBM Corp.'s Thomas J. Watson Research Center. He found that the excimer laser, instead of burning away biological specimens he tried it on, made the tissues chemically decompose, giving incredibly clean cuts only a few millionths of an inch deep. It occurred to doctors at Columbia University that perhaps the technique could be used to reshape corneas and improve sight.

Now researchers at a half-dozen locations have shown that the process does indeed work and that the corneas heal clean and crystal clear. The first human trials will be on volunteers who are about to lose an eye (from cancer, for example) and have nothing to lose if the experiment doesn't work. The highly promising technique could be in general use in two or three years.


Editor-in-Chief

THE WORLD'S

If Congress approves its construction, the Superconducting Super Collider will be mankind's largest device ever, and one of the costliest, at an estimated \$4.4 billion. Purpose of the giant accelerator: to plumb the mysterious domains of particle physics in search of the fundamental entities and forces that govern the nature of all things.

By ARTHUR FISHER

Throw deep." That's the red-lettered message on a sign tacked to a bulletin board in a Lawrence Berkeley Laboratory building high above San Francisco Bay. And that's what President Reagan, quoting pro quarterback Ken Stabler, said at the end of a meeting to discuss the pros and cons of building the SSC, or Superconducting Super Collider. In short, go for the big one.

Big it is. Bigger than those wonders of the ancient world, the Pyramids of Egypt and the Colossus of Rhodes. When it is completed in 1996, the SSC will be (assuming Congress goes along with the administration's proposal and votes for the necessary funds—\$4.4 billion in 1988 dollars) the largest particle accelerator ever built, dwarfing Fermi National Accelerator Laboratory's Tevatron, in Batavia, Ill., and the Center for European Nuclear Research's Large Electron-Positron Ring, now being built near Geneva, Switzerland. (See drawing for size comparison.) At a site yet to be chosen, the SSC will consist of a race-track-shaped tunnel 52 miles in circumference, 10 feet in diameter, and buried at least 30 feet underground.

Inside the tunnel, two rings of superconducting magnets—some 10,000 of them, strung like pearls on narrow, evacuated particle beam pipes—will focus and guide two beams of protons traveling in opposite directions. The protons race around their tracks millions of times, getting an extra jab of radio-frequency energy with each circuit, until they are traveling at nearly the speed of light. At special chambers called interaction halls, the opposing beams will cross over and collide with an energy 20 times greater than any before achieved: 20 trillion electron volts (TeV) per beam, for a total of 40 TeV. Massive detectors will record and analyze the debris left by these titanic collisions.

Why have particle physicists been clamoring for such a monster? Why does it have to be so much bigger and more powerful than any other accelerator? Wouldn't something only one-half its size—still a big jump upward—have sufficed? And why has an administration opposed to "budget-busting" decided to back the SSC, even in the face of complaints from other scientists that it will divert too much money from other worthwhile projects?

The administration's rationale was given by John S. Herrington, Secretary of the Department of Energy, in announcing the President's approval last February. He termed the decision "a momentous leap forward for America and science and technology. . . . The Super Collider holds the potential for a new generation and a new revolution in science, education, technology, and commerce. Like Apollo, it will have spinoffs, discoveries, and innovations

that will profoundly touch every American. . . . Once again, this nation has said there are no dreams too big, no innovation unimaginable, and no frontiers beyond our reach."

The particle physicists' reasoning can be put less grandly: They are stuck. Without powerful new experimental tools, they cannot progress beyond their present theories of the nature of matter and energy, space and time. To understand why, consider how we got to the so-called Standard Model of particles and forces.

Atom smashing

The route to that model has been paved with some 30 years of experimental data from accelerators. Just as the telescope is the basic tool of the astronomer, and the microscope of the biologist, the accelerator serves the physicist as a way to look inside the atom. It does this with what has been called the "Swiss watch" method: To find out what is inside a Swiss watch, bang two of them together and see what comes out. High-energy physicists have been banging atomic particles together with ever-increasing force in the instruments designed for that purpose—accelerators.

Until about 20 years ago, all accelerators were of the type known as fixed-target, in which a beam of speeding particles smashes into a stationary target. New technology brought the advent of colliders, in which two counter-rotating beams collide head-on at designated points. The advantage of the collider design is that almost all of the kinetic energy borne by the two particles goes into creating new kinds of matter, whereas in the fixed-target design most of the single particle's energy is wasted in contributing to the forward motion of the collision products. The difference is tremendous. The useful energy of the SSC will be 40 TeV, the sum of its twin 20-TeV colliding beams. If one of these beams were simply aimed at a fixed target, the useful energy would be only 0.2 TeV.

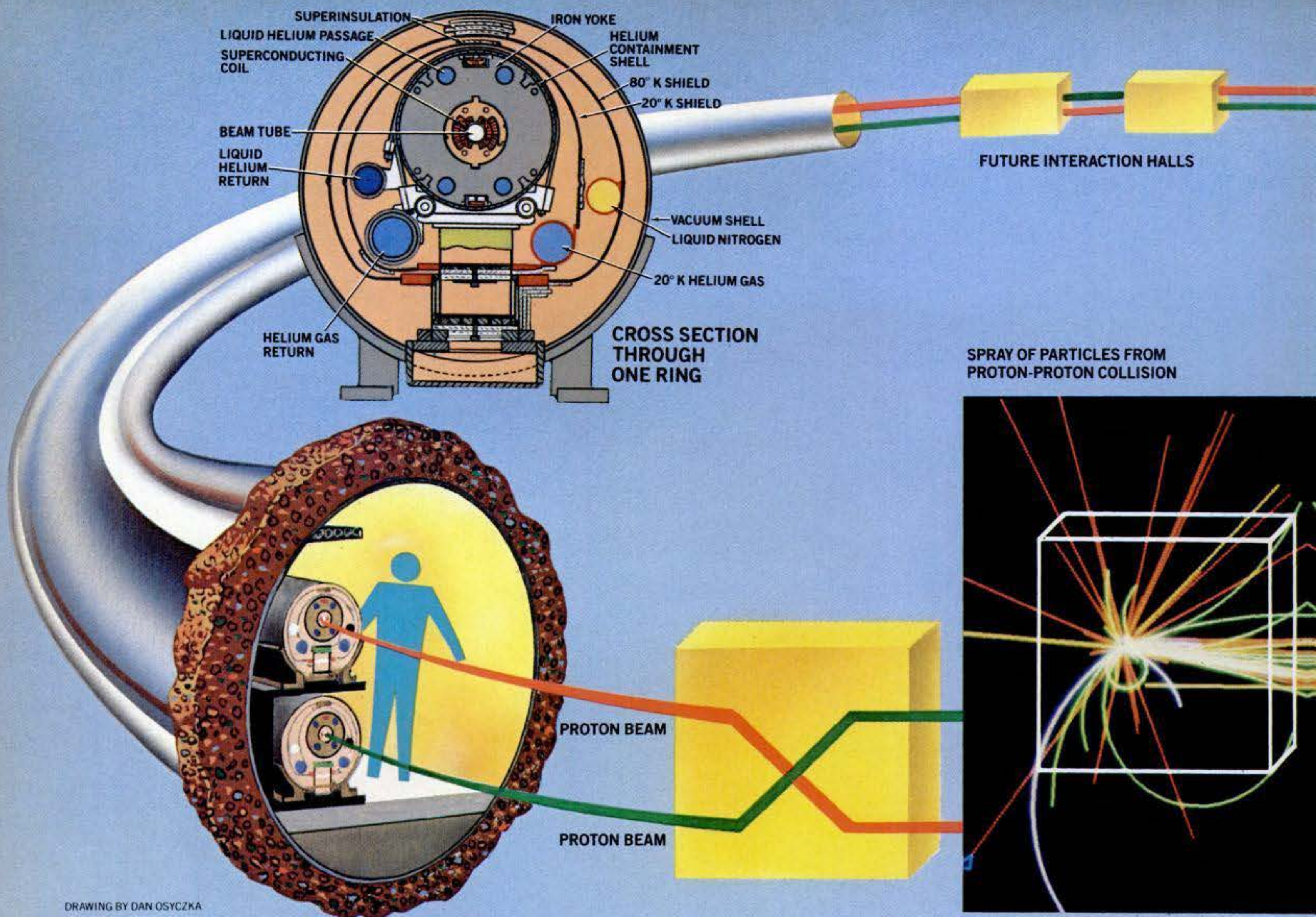
And the energy level is crucial. Because matter and energy are interchangeable in the nuclear domain, the more massive a particle, the more energy is needed to create it in the innards of an accelerator. One salient example: Particles called the W's and the Z were predicted long before they were actually created and identified in 1983, at the Super Proton Synchrotron at the Center for European Nuclear Research ["Cosmic Order," May '83]. They were simply too massive to have been seen until that collider

Continued

The SSC, to be housed in an underground race-track-shaped tunnel, would be the largest particle accelerator ever built. Here, the accelerator's 52-mile circumference is superimposed on a satellite view of Washington, D.C.

BIGGEST MACHINE





DRAWING BY DAN OSYCZKA

The object of the SSC is to collide two beams of counterrotating protons (red and green lines) with an energy of 40 TeV. Each beam travels in a separate ring, consisting of a narrow evacuated pipe surrounded by cryostats and superconducting magnets. The liquid helium cryostats cool the rings to just 4.3 Kelvin. Two kinds of magnets are used: dipoles, which bend the proton beams, and quadrupoles, which focus them. Each ring has 3,840 dipoles and 888 quadrupoles, plus other special-purpose magnets. The dipoles are about 57 ft. long; the quadrupoles, about 14 ft. long. A cross section of one

ring through a dipole appears above.

The protons first pass through a linear accelerator, and from there enter a series of three booster rings, each accelerating them to a higher energy. They enter the main rings—130 trillion protons per ring—at 1 TeV, and are ultimately accelerated to 20 TeV by radio-frequency quadrupoles in millions of swings around the SSC. The beams are made to collide in interaction halls; six will eventually be built. The collisions will generate sprays of many kinds of particles, possibly including such as-yet-unseen entities as the Higgs boson and others.

A computer simulation of one such proton-proton collision in the SSC is here superimposed over one of the interaction halls. The colored tracks are the paths of different particles.

The giant scale of the SSC is shown in the illustration at right, in a comparison with three other large accelerators (two of them under construction) and Manhattan Island. The three accelerators are Fermilab's Tevatron, now operating; a Soviet collider at Serpukhov; and the Large Electron-Positron Ring, in Switzerland. The SSC is actually shaped like a race track, with straightaways and curved ends.

crashed beams of protons and antiprotons together with a total energy of 630 billion electron volts (GeV).

The discovery of the W's and the Z—called intermediate vector, or force-carrying, bosons—confirmed a prediction of a theory unifying two of the fundamental forces in nature, electromagnetism and the weak nuclear force, and more or less capped the Standard Model.

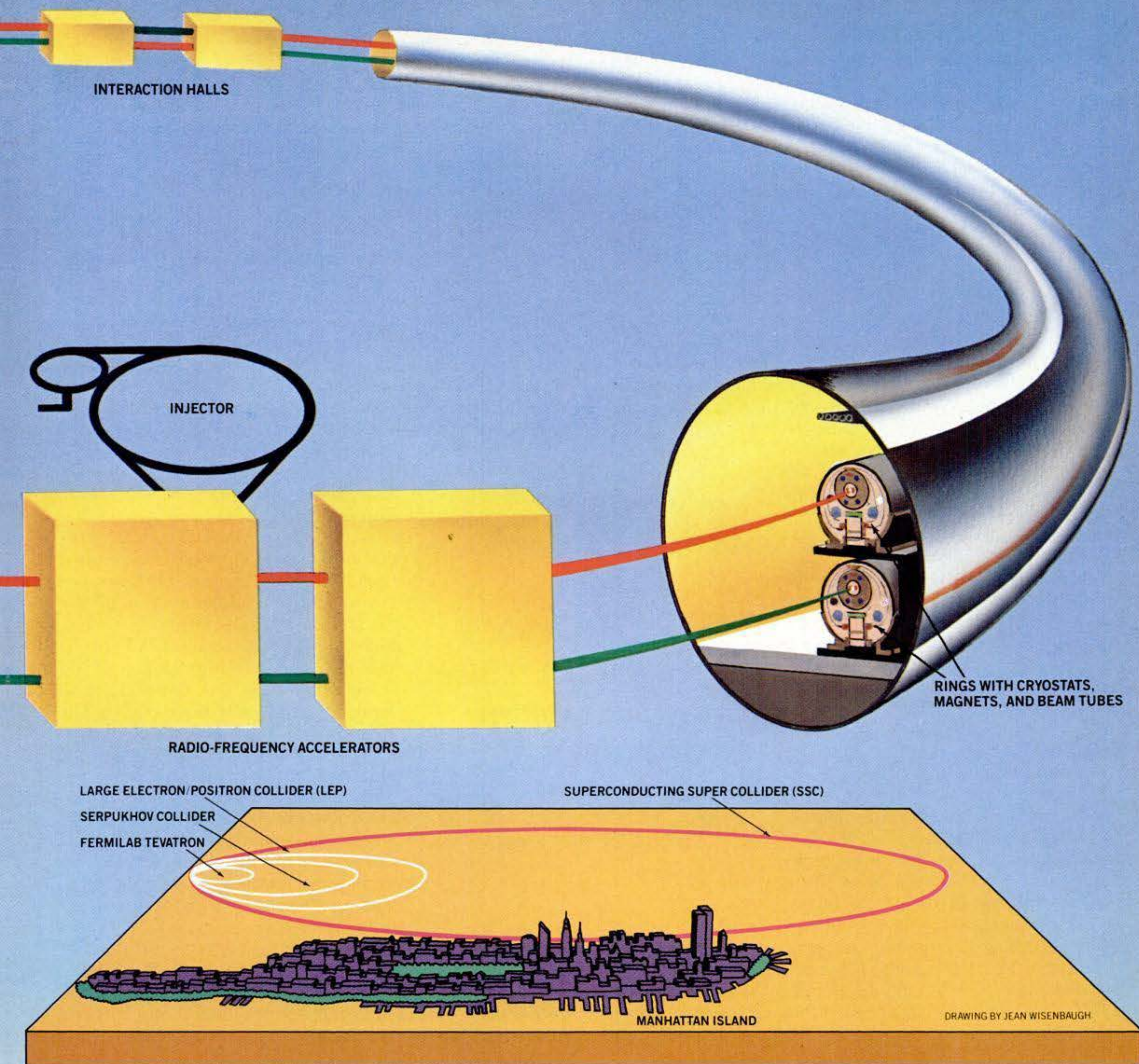
Going deeper

On a recent visit to Fermilab, I asked Leon Lederman, the facility's wise and witty director, about the status quo and the need to go beyond it. "If you summarize all the physics up to a certain energy level," he told me, "it is called the Standard Model. Briefly, it says the world's fundamental building blocks are six quarks and six leptons and their antiparticles. The quarks and leptons seem to fall naturally into three families, grouped according to their properties. Then there are four forces that govern how these particles combine and interact: electromagne-

tism, the strong nuclear force, the weak nuclear force, and gravity. In turn, these forces are carried by other particles: photons, gluons, and the W's and Z. Gravity, we don't know much about... but there's hope.

"So that's the Standard Model. It identifies the fundamental building blocks. It provides a powerful new mathematical formulation, known as gauge-symmetry theory, for the four basic forces. And it takes a giant step—the formulation of the electroweak theory—in the fifty-year search for a unifying principle. It incorporates the two earlier revolutionary theories of the twentieth century, the quantum theory and special relativity. And it accommodates all the data coming out of all the accelerators that have ever been built since the Leaning Tower of Pisa. So it is a very powerful synthesis. You can write all the rules down in a couple of pages.

"Of course," Lederman continued with a grin, "you can't quite fit it on a T-shirt, my favorite model for the correct theory.



"All of this has brought us to a new level of understanding of physical laws. And yet, the Standard Model has ticking away in it some very dramatic incompletenesses, some serious defects. For one thing, it does not account for the masses of the quarks and leptons, or for the pattern of apparent families of particles. Why are there three families? Are there any more?"

There is also much uneasiness, says Lederman, because a good theory should be essentially simple. The Standard Model contains about 20 parameters—numerical values that are just there rather than being predicted by theory. "Designing the world this way," Lederman said, "the Creator would have had to set twenty dials carefully at seemingly arbitrary values."

There is an even more serious defect, says Lederman. The carriers of the weak nuclear force, the W and Z bosons, are very massive—100 times more so than the proton. But gauge symmetry—essential to the unification of forces—implies that the force carriers have zero mass, as

does the photon. Current unification theory holds that at some enormously high energy regime, such as the one that reigned in the first instants after the Big Bang, all the forces were symmetrical, and all their carriers massless; but at lower energies, the symmetry became broken. Just how does the symmetry break?

"This apparent breaking of symmetry is one of the most unhappy elements of the Standard Model," said Lederman. To get around it, to provide a symmetry-breaking mechanism, theorists invented an as-yet-undetected particle called the Higgs boson, named for Dr. Peter Higgs, now at Edinburgh University in Scotland. The Higgs boson hypothetically is the carrier of yet another force, which acts on the W and Z particles to give them large masses. Its properties are "delicately chosen," said Lederman. "The Higgs mechanism is very awkward... it could be said that it is a rug under which is swept our ignorance of the meaning of structure or lack of structure for

Continued

an elementary particle. The Superconducting Super Collider is specifically designed to confront the Higgs theory with decisive data."

How? Theory predicts that the Higgs boson, if it exists, cannot have a mass greater than 1 TeV. "Something has to happen at one trillion electron volts," said Lederman. "Some new physics has to be there to account for this business that we lump together and call Higgs." Then isn't it overkill to design the SSC with an energy of 40 TeV?

The answer is no, for the numbers are deceiving. The energy actually available to create new entities depends on the particles that are colliding. "In a machine that accelerates electrons and positrons and causes them to collide in head-on collisions, that number is very easy to come by," Lederman told me. "It is simply the sum of the energies of the two counterrotating beams. But the situation is different with a proton, which is a complicated object, not a single pointlike particle like an electron. A proton is made up of three quarks that are held together by gluons. So when you accelerate a proton, you are carrying with it the baggage from lots of other things, and the proton's energy is actually shared among those things."

The thing that creates new physics, says Lederman, is the collision of these constituents of the proton and anti-proton—a quark-quark or gluon-gluon collision. And that energy is only a fraction of the total, a fraction that varies in complex ways.

One useful analogy is to think of a proton-proton collision as banging together two bean bags rather than two billiard balls. The energy level of the SSC was chosen to ensure that the "beans" would collide with an energy of at least 1 TeV. At this level, the door to new physics, now locked, springs open. Investigators will be seeking out, in addition to the Higgs boson, the "top" quark, which the Standard Model predicts but which has never been detected with certainty. "There is a very rich spectrum of particles proposed by our friends who developed supersymmetry theory," Lederman said. That theory demands heavy particles with Runyonesque names like "winos," "sleptons," and "Higgsinos." Their appearance or nonappearance in the SSC may allow physicists to learn which of several competing post-Standard Model theories is the correct one.

"On the other hand, we may be in for a tremendous surprise," Lederman said. "Some totally new and unexpected picture of nature may emerge."

So much for the reasons the SSC needs to be so powerful. Why does it have to be so big?

Because protons carry an electrical charge, they can be accelerated by an electromagnetic field such as radio waves. Protons in the SSC will be accelerated by radio-frequency fields. Each passage through such a field slightly boosts their speed and therefore their kinetic energy. To achieve very high energies, the protons must receive millions of such kicks, which means they must travel along a closed path, usually a circle or race-track-like oval. (To accelerate protons to 20 TeV in one straight pass would require a tube more than 600 miles long.)

And that's the problem. Like any other moving object, protons and all other particles obey Newton's Law of Inertia: They want to move in straight lines. To confine them within a closed curve, their paths must be bent by powerful magnets. And the higher the energy of the particle

beam, the more "rigid" it becomes—the harder it is to bend it along a curved path. So for a given magnet strength, the higher the energy of the protons, the greater the path's circumference must be; increasing the circumference reduces the sharpness of the bend.

In fact, the 52-mile circumference chosen for the SSC is a trade-off between size and magnet design. Original proposals had the circumference at anywhere between 50 and 100 miles. The larger circumference would have saved money in magnets, but the collider would not have fit at many of the suggested sites (some 20 states are eager for the SSC to be in their territory), and a larger tunnel would have cost more to excavate and build. The race-track shape, with its straight passages, is simply more convenient for experimental purposes than a circular layout.

Such decisions have been the concern of a band of scientists and engineers called the SSC Central Design Group. After the administration's go-ahead was announced, I visited the group's director, Cornell University physicist

Maury Tigner, at SSC headquarters. It is on the grounds of Lawrence Berkeley Laboratory, high above the main University of California, Berkeley, campus, at the end of a long hill-climbing street appropriately named Cyclotron Road. Ernest O. Lawrence invented the cyclotron, first of the modern breed of accelerators, in 1930, for which he won the Nobel Prize. It was five inches in diameter.

Tigner's office was down the hall from the bulletin board with the "Throw deep" sign. It was filled with the usual stacks of files, documents, and books, with one slightly incongruous note: Sandwiched between an engineering handbook and a physics text was a volume of the poems of Wallace Stevens. Finding a "resonance" in some of the harder poems, Tigner said, was a challenging and satisfying intellectual experience.

So, of course, is particle physics. "We regard the field," Tigner told me, "as part of a continuum that stretches back in history—part of the effort to understand the world around us, one of man's premier intellectual and cultural activities. We've been using accelerators to do science ever since the late twenties and thirties, when Cockcroft and Walton and Ernest Lawrence showed us how to make instruments that achieved a resolving power of about nuclear dimensions.

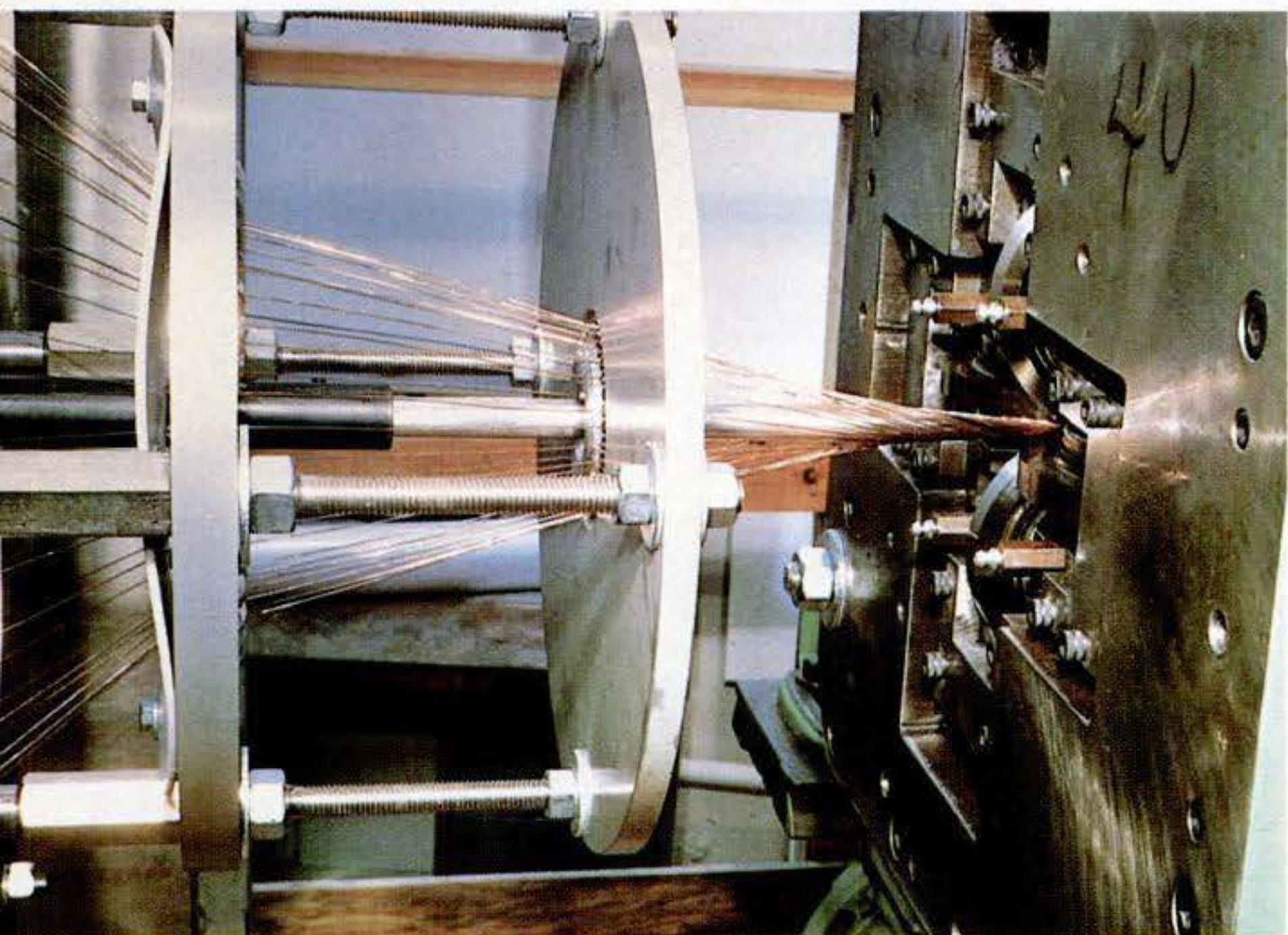
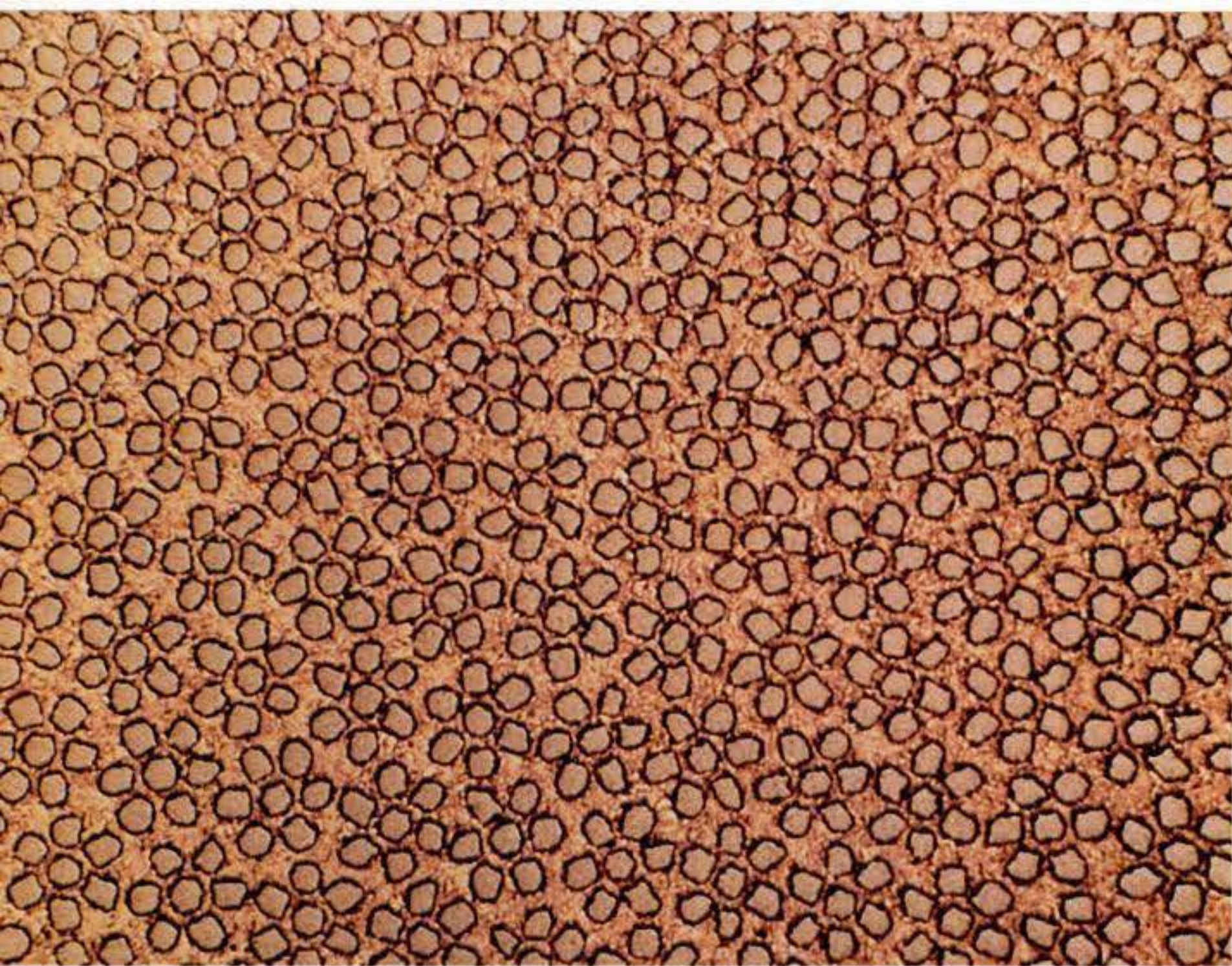
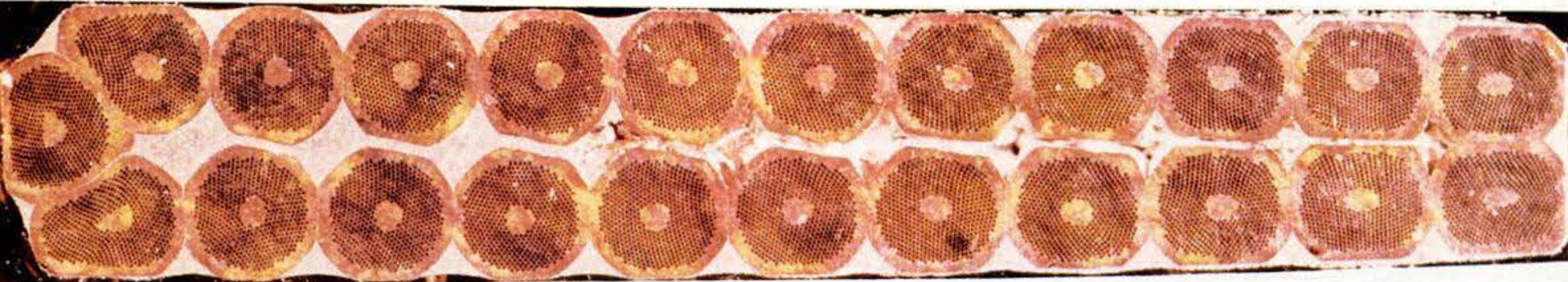
"Since that time, this science has always been big science, requiring major resources. So the followers of this trail have always had to organize themselves to share the resources, much as astronomers do with their telescopes. As the needed instruments have become bigger and more expensive, they've become fewer and fewer in this country and around the world, and the time needed to plan them and bring them to reality has grown longer and longer." (The United States had 22 modern accelerators in 1953; now there are four.)

I asked Tigner about the genesis of the SSC.

"We can trace it back to the early seventies, when people began to understand that the accelerators then in existence were only going to go so far in giving us access to the energy that was needed to press beyond our understanding. Even then, the Standard Model was pretty much in place, and we were already beginning to perceive its problems—the many fundamental questions left un-

[Continued on page 110]

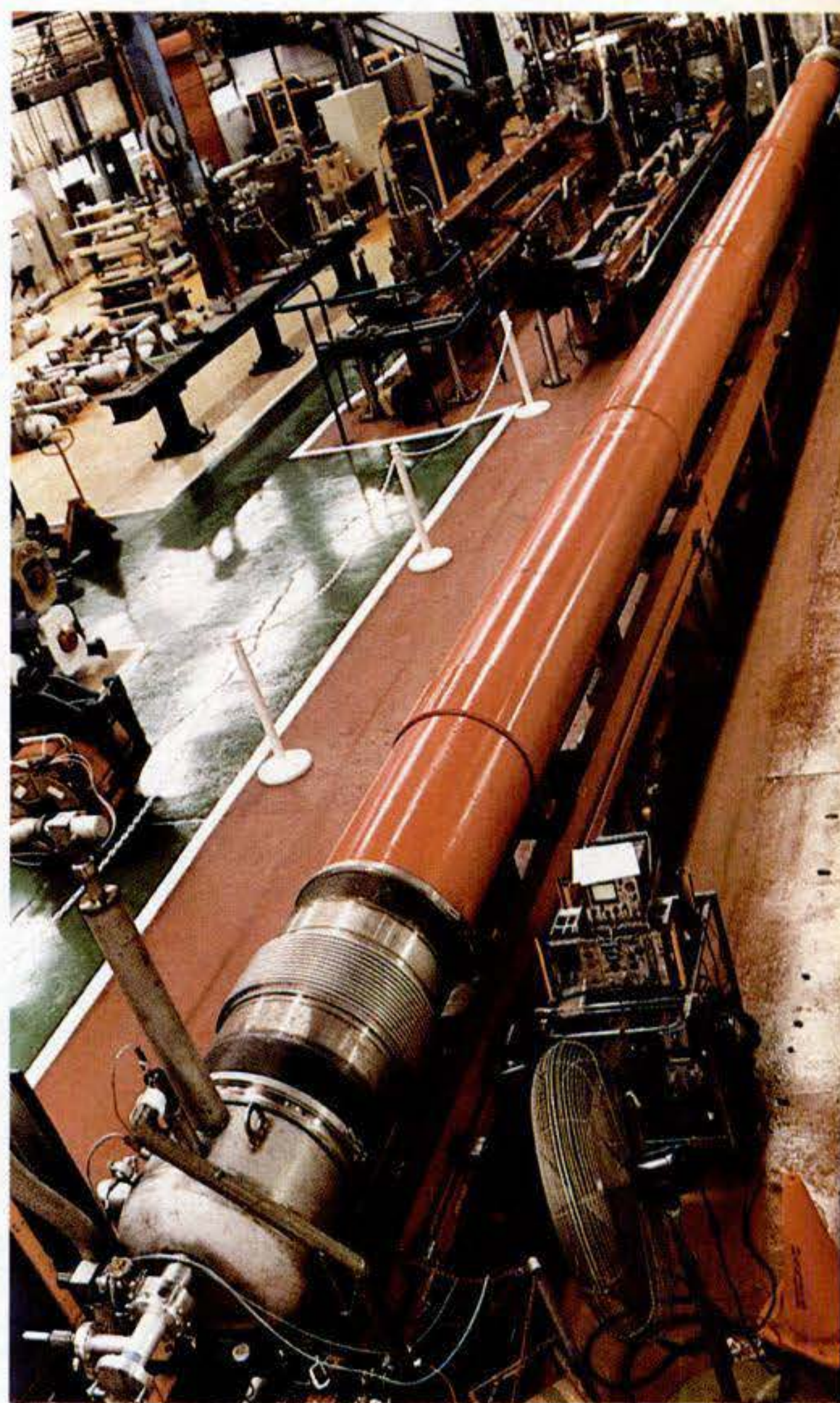
“Think of a proton-proton collision as banging together two bean bags rather than two billiard balls”



Superconducting niobium-titanium wire cable for the SSC's magnet coils is made with 23 strands of wire, clearly seen in the cross-sectional photo at top. It has a slightly wedge-shaped profile so that it conforms to the shape of the magnet coils. The cable itself is only about $\frac{1}{3}$ in. wide. Each wire averages about one-tenth of that. The internal structure of the wire with its thousands

of ultrafine filaments is clearly visible. The middle photo gives a magnified cross-sectional view of these niobium-titanium alloy filaments. There will be roughly 13 miles of superconducting wire in the SSC.

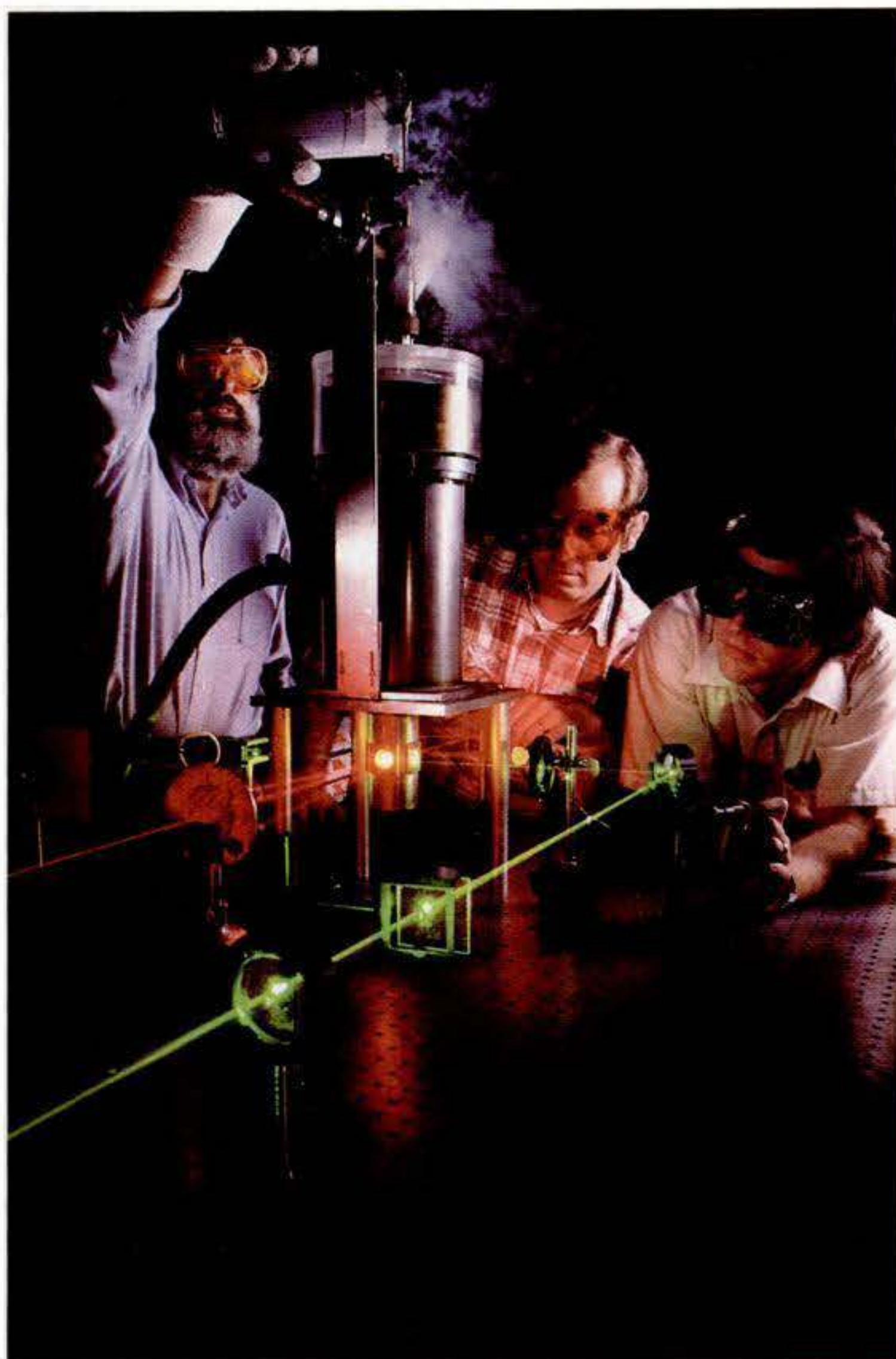
The bottom photo shows the specially designed cabling machine for fabricating the SSC's superconducting wire cable. Individual wires are



brought together from separate spools, drawn through a guide, and then twisted before being flattened. The device is capable of handling up to 36 strands.

The photo at right shows one of the giant dipole superconducting magnet assemblies being tested at Fermi National Accelerator Laboratory, in Batavia, Ill.

MOLECULAR



A tunable red laser is directed into a vat of liquid helium to write on IBM's submerged photon-gated materials.

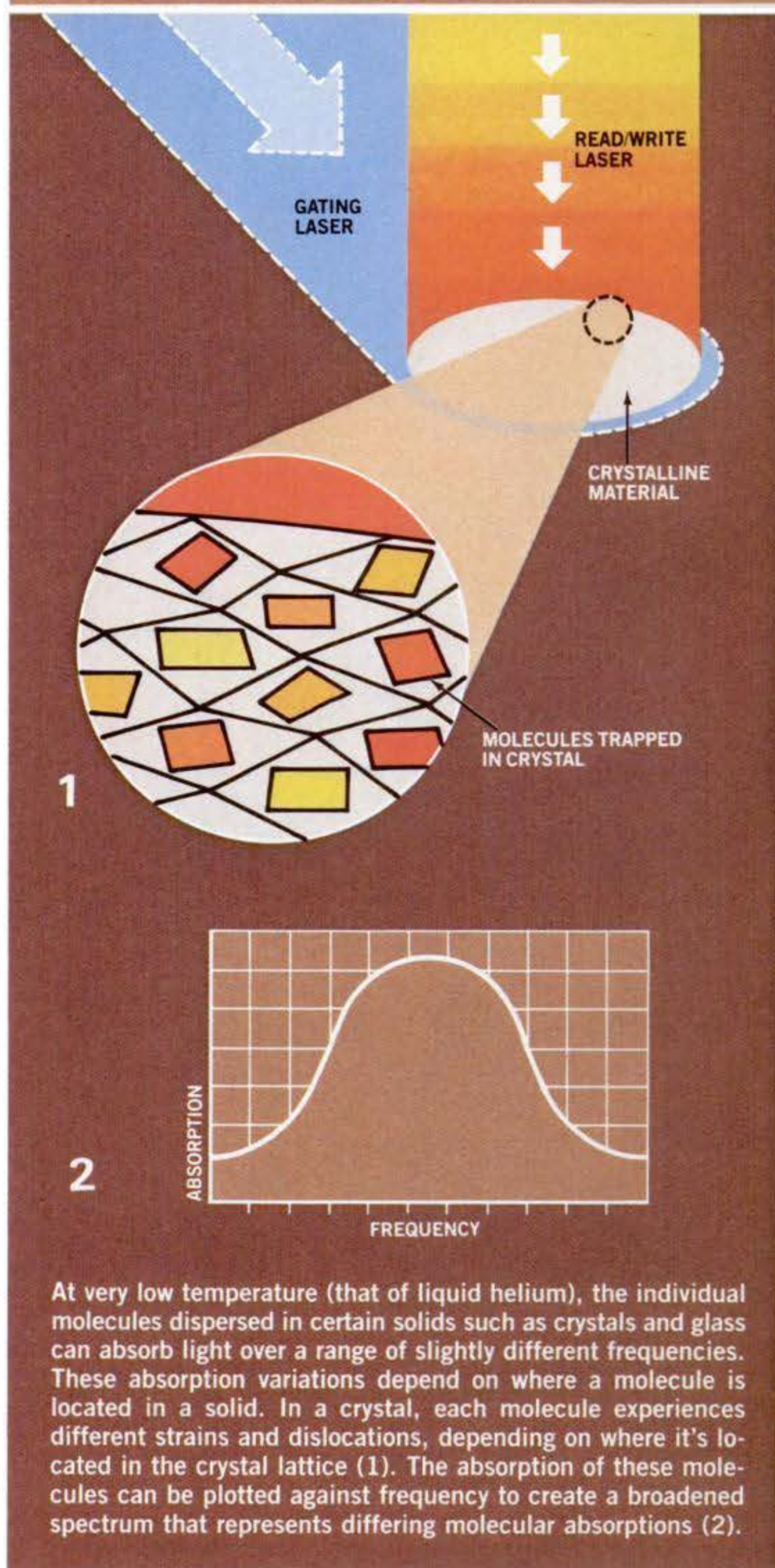
The storage capacity of a laser disc is limited by the size of a recorded laser spot. IBM researchers are overcoming that limitation by developing a computer memory that would store one thousand times more information in the same spot. The key is to store data in molecules trapped in crystals.

By **NAOMI J. FREUNDLICH**
Drawings by Mitchell J. Albala

The rudiments of the advanced computer memory system wait submerged in a three-foot-high vat of liquid helium at -450 degrees F. Key components are small wafers made from an exotic crystalline material. Red and green lasers, directed through the vat, home in on a tiny spot on the wafer. The red laser is then rapidly tuned

SAN JOSE, CALIF.

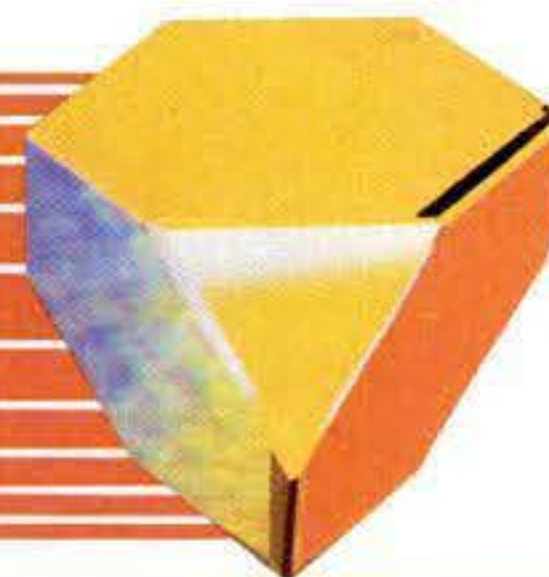
Data-storage system



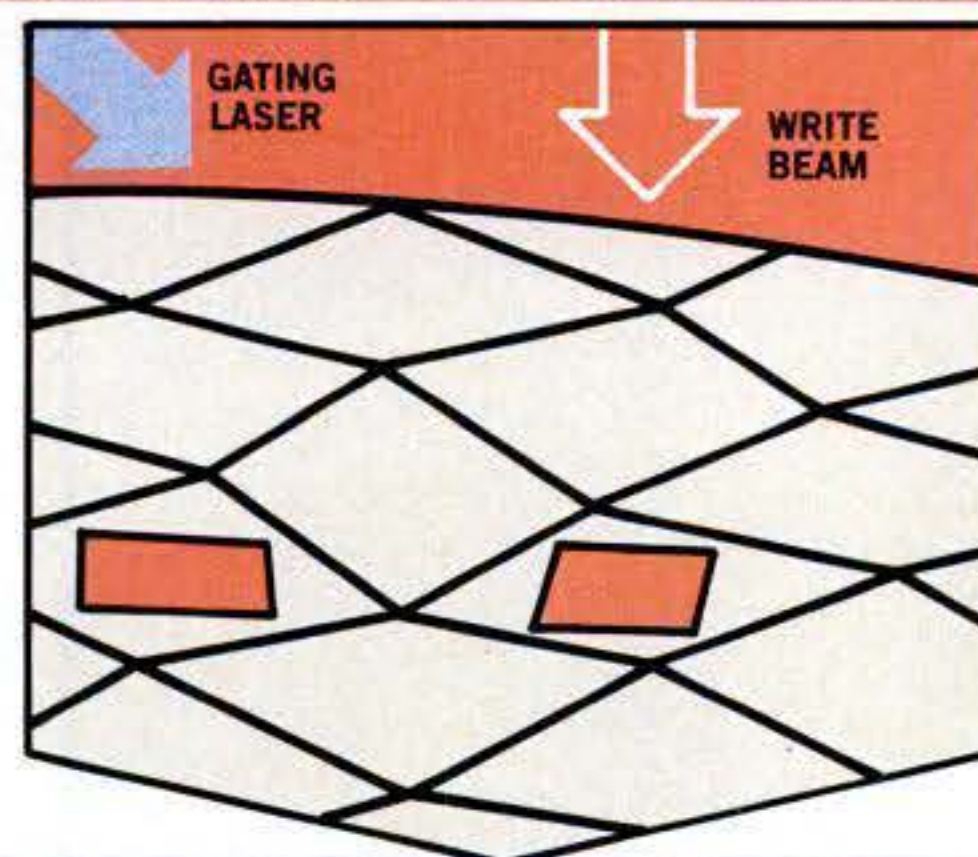
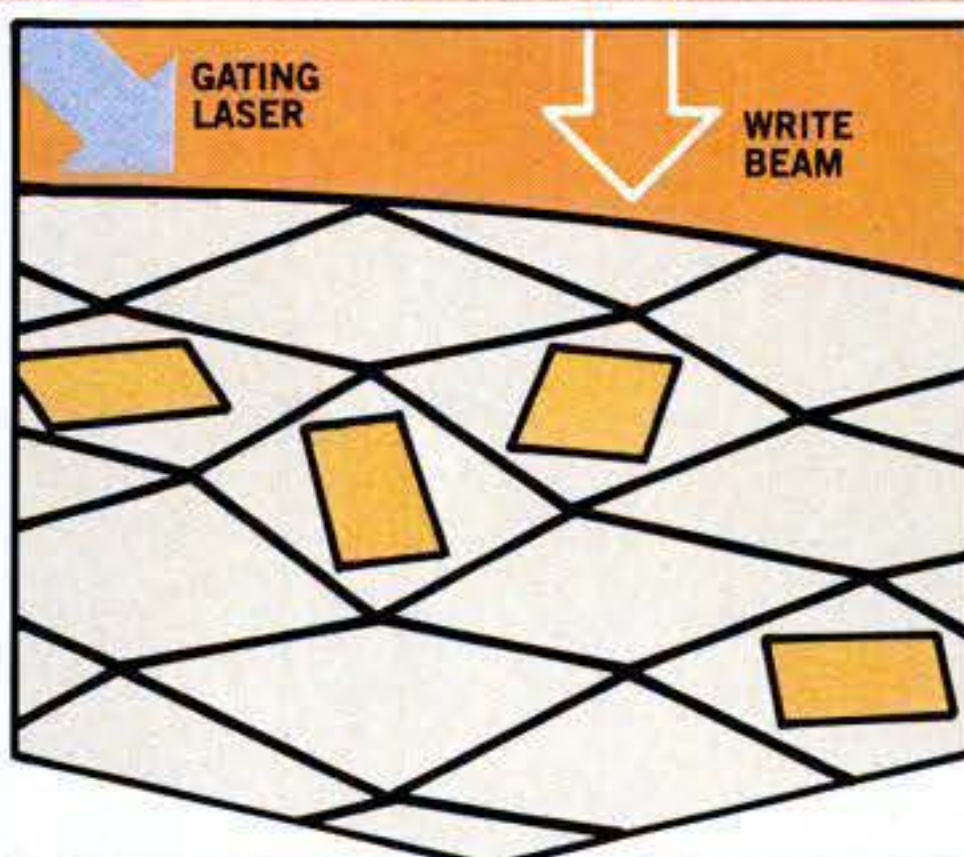
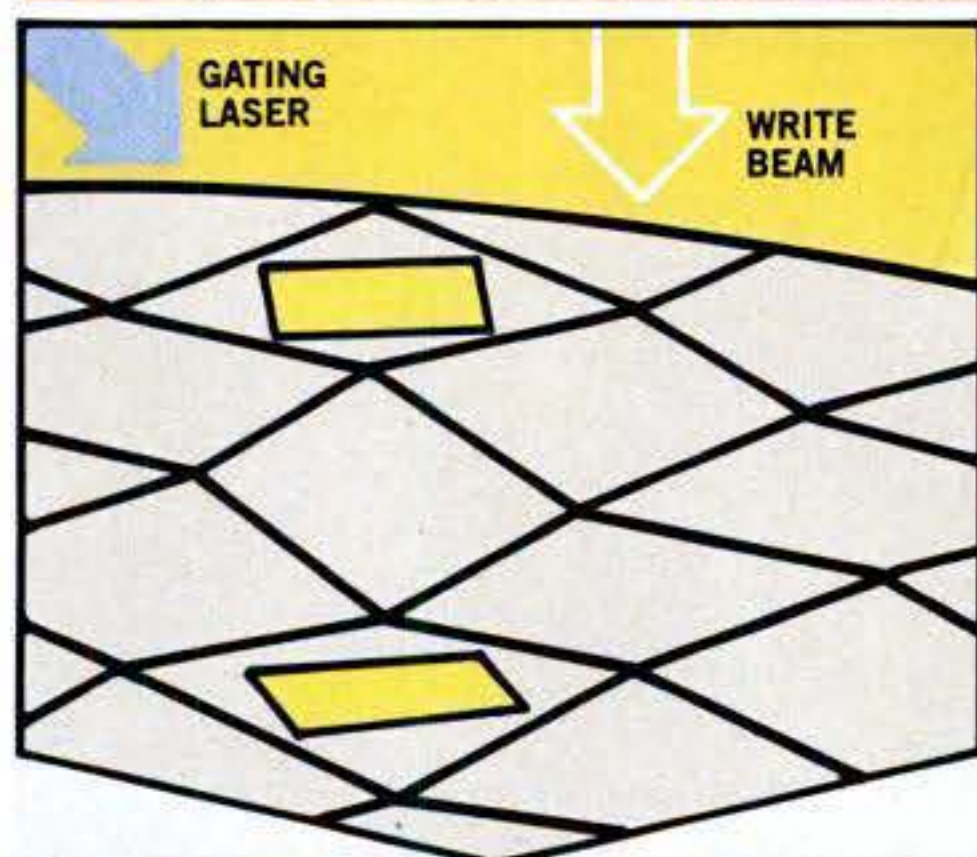
through many discrete intermediate frequencies—changes too subtle to be detected by the human eye. When a low-power laser probes the same wafer spot, a photodiode detector records several peaks, or blips, as light is transmitted through the wafer. “Those blips are signaling spectral holes where data have been recorded,” says Roger Macfarlane, a research scientist at IBM’s high-tech Almaden Research Center here.

But the blips signify more than that. These submerged

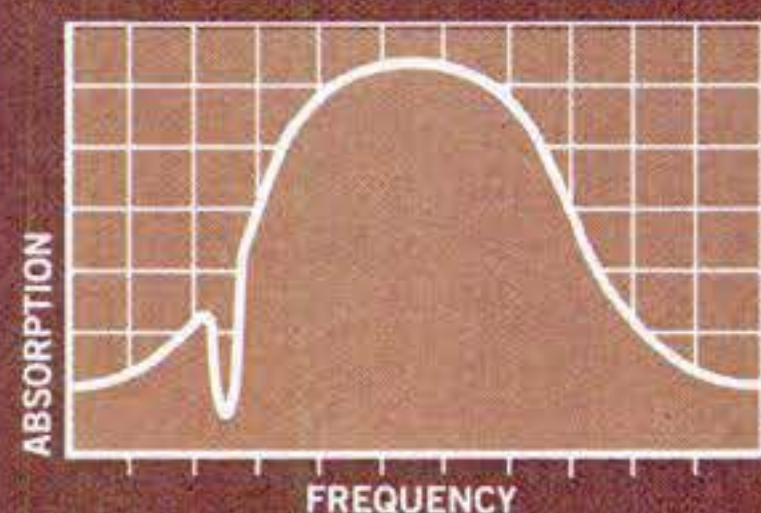
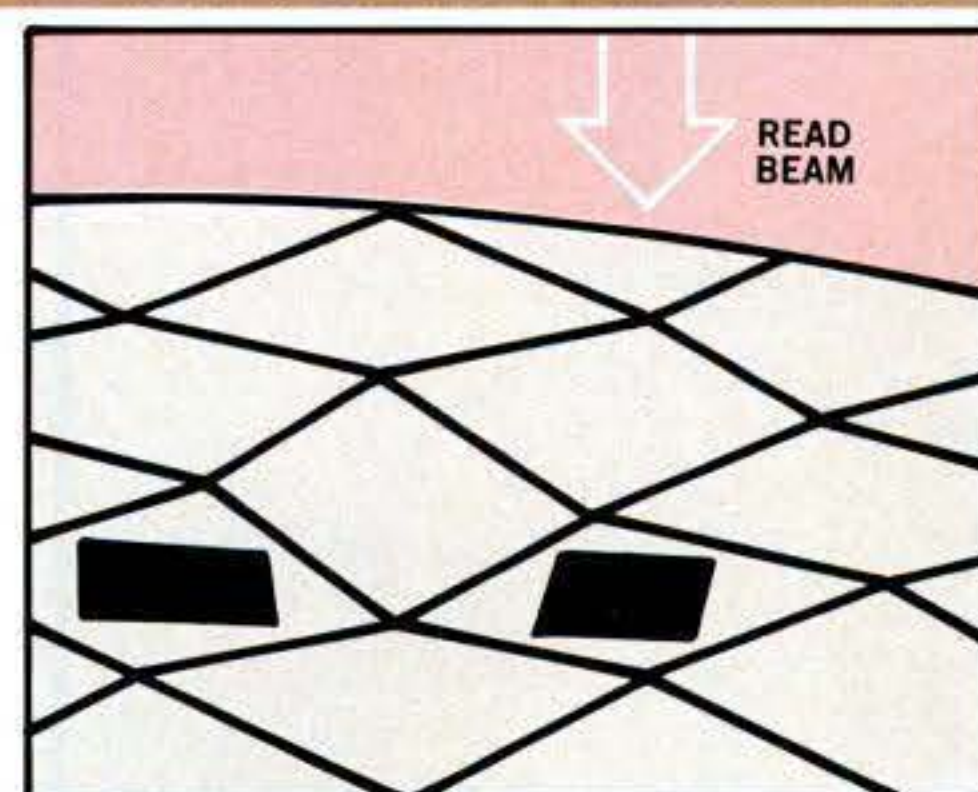
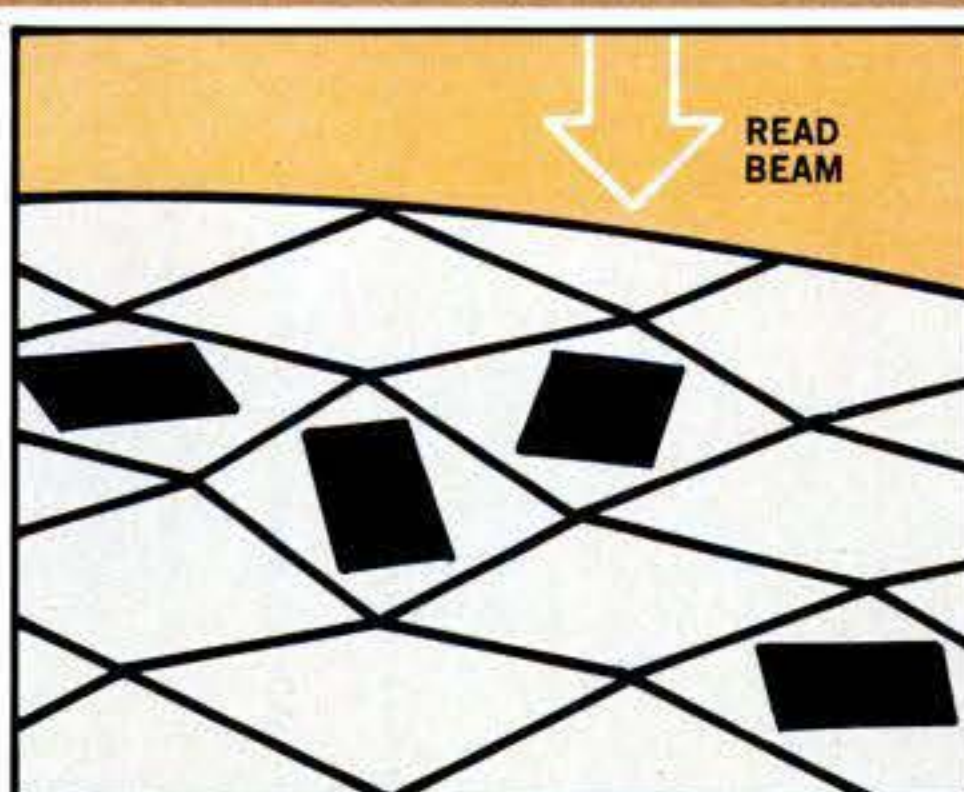
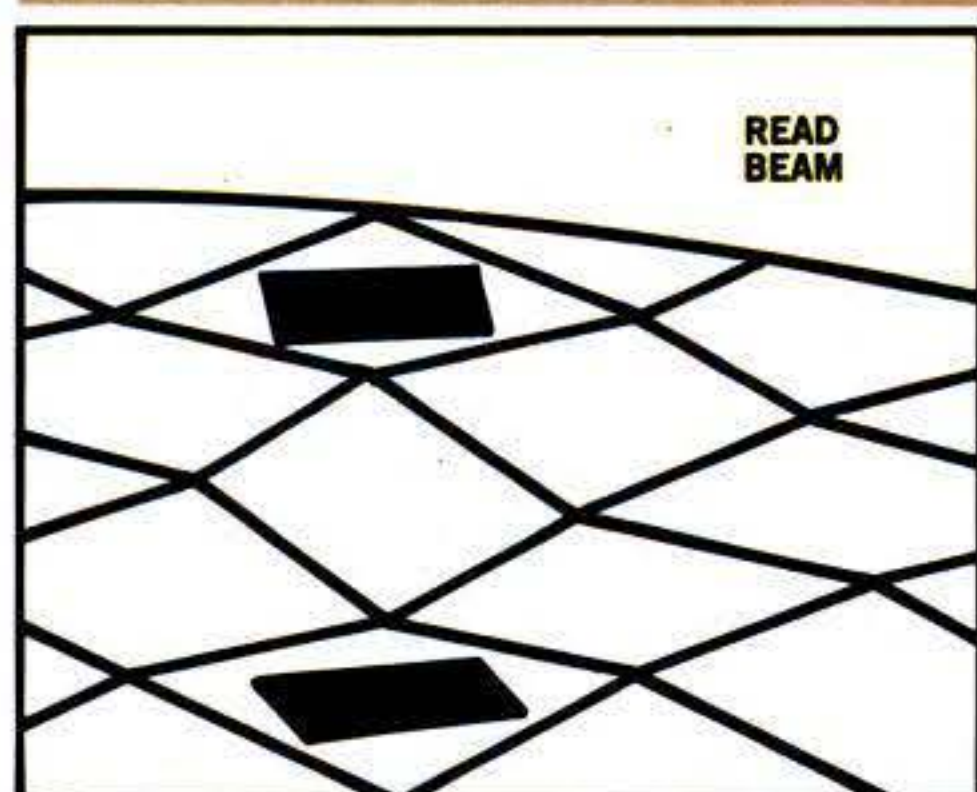
MEMORY



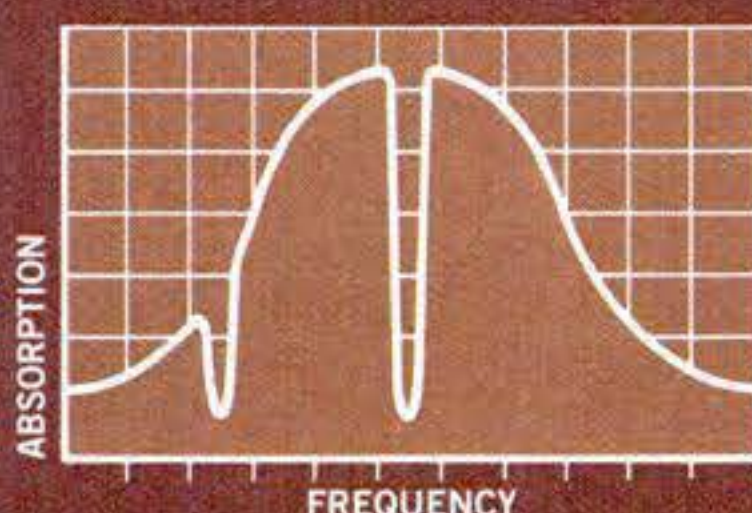
Writing



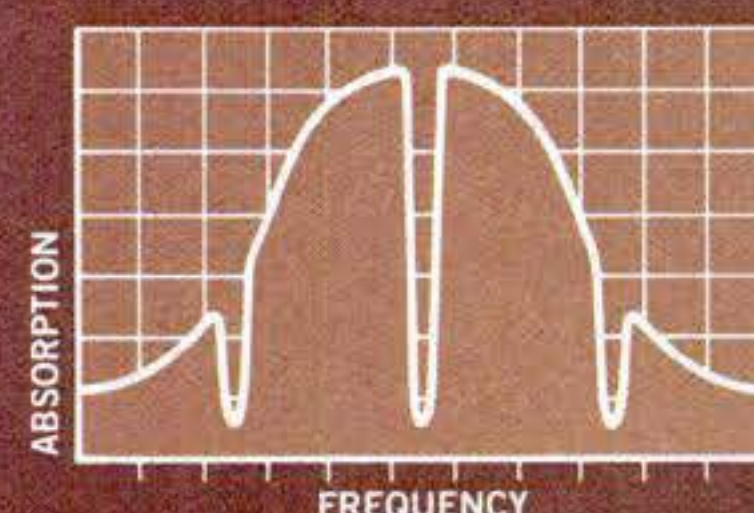
Reading



IBM researchers are taking advantage of this property of molecules trapped in certain solids at low temperatures. To record data in a frequency-domain storage system, first a gating laser (blue arrow) must be switched on. Its function is to provide the threshold energy for a digital 1 to be recorded. Digital 1s are recorded when



the second laser, a laser tuned to one of the intermediate frequencies, is pulsed. This dual-laser combination bleaches, or changes the absorption of, a particular group of molecules (top row). The bleached molecules no longer absorb at their signature frequency. To read data (middle row), the gating laser is shut off, and at low power, the



writing laser is tuned through all its intermediary frequencies. Where information has been recorded (a digital 1), light passes through the medium, leaving a dip in the absorption spectrum (bottom row).

To erase data, a light pulse from another colored laser restores absorption at the signature frequency.

wafers and their spectral holes signal the beginning of a new realm of computer storage—using hundreds of slightly different laser wavelengths to write vast quantities of data into the individual molecules scattered throughout a crystal. Years of research remain, however, before this laboratory work can become a commercial product.

A winding canyon road curving upward past acres of parched range land is the only approach to IBM's new Almaden research facility. Inside the modern green metal-

and-glass building, research scientists pad around in blue jeans and leather sandals, and administrative types are scarce. Almaden houses some of IBM's most advanced research—ideas that might hit the marketplace in a decade or so, if ever.

The molecular data-storage system—or frequency-domain optical storage—is one of these projects. If successful, it will put even the most capacious computer mem-

[Continued on page 118]

FROZEN TOOLS

After a slow descent to -300 degrees F and back to room temperature, steel tools may wear better—sometimes spectacularly better. So may copper welding electrodes and carbide parts. Yet this relatively inexpensive process is not widely applied. Why? The treatment doesn't always work, and the scientific underpinnings have not been proved.

By V. ELAINE GILMORE

Northrop Corp. tested some specially treated high-speed steel drill bits and found that they cut twice as many holes in titanium plate as did identical drills that hadn't been treated.

Mallory Corp. had some of its copper welding electrodes subjected to the same treatment and found it extended average life from 20 to 120 hours.

Tom Willis, one of the country's top-10 amateur dirt-bike racers, had the engines and other parts of his motorcycles treated. Thanks to the treatment, he says, he seldom has a breakdown, even in the torturous environment of desert racing.

The treatment in all of these cases was a long, slow, and very deep freeze—to around the temperature where liquid nitrogen boils, -320 degrees F. Called deep-cryogenic processing, it is done by a handful of firms in the U.S. All have reams of testimonials from impressive clients attesting to the benefits (mostly) of the freeze: Steel cams and gears wear better, cutting edges stay sharp longer, and welding electrodes make more welds, the clients report. Sometimes the improvement is dramatic: A part may last many times longer than an identical unfrozen part.

Cryogenic processing is relatively inexpensive, adding from 10 to 15 percent to the cost of a tool. And unlike wear-resistant coatings (such as titanium nitride), you don't lose the benefits when you regrind a tool.

Proponents of the freezing treatment make some oddball claims as well: Treated golf balls go farther, they say, and nylon panty hose wear longer. A violinist claims his violin strings not only last longer but sound "brighter" after the chilly treatment.

Why should deep freezing have any of these effects? "Some research has been done, but there are more questions than answers," admitted Dr. Jeffrey Levine, a physicist and president of Applied Cryogenics, a processing firm in Newton Upper Falls, Mass.

The process

Levine's small office, decorated with posters of penguins ("our mascot," he noted with a smile), leads to a long, narrow room where the super refrigerators reside. "This is our original cryogenic processing machine," Levine said, pointing to a white cube about six feet square. Beside it sat a tank of liquid nitrogen. Levine and his partner, Bruce Norian, a mechanical engineer, designed and built the processor. "It's mostly insulation," Levine told me.

The machine's center cavity of galvanized steel is surrounded by an air space. When parts are treated, liquid nitrogen flows into the space; it does not touch the parts. If it did, many would fracture from the thermal shock.

The temperature descent is very slow. Levine and Norian designed a controller that constantly compares the internal temperature with a set time-temperature profile and meters in the liquid nitrogen accordingly. "It's roughly an eight-hour descent from room temperature down to about minus three hundred degrees Fahrenheit," Levine explained. That temperature is maintained for 10 to 20 hours. Then begins an even slower temperature ascent—as much as 30 hours to reach room temperature.

Finally, the treated parts are tempered by heating to 300 degrees F above zero. The entire cycle takes approximately 60 hours. Applied Cryogenics charges \$5.75 a pound for the treatment, with a \$35 minimum per customer. The company also sells high-tech computer-controlled cryogenic

Continued

A batch of industrial tools comes out of the deep freezer at Amcry Corp., a cryogenic processing company. Elliott Pucker, president of Amcry, presides.



PHOTO BY JAMES CACCARO

treatment machines that Levine and Norian design themselves and build to order.

They are not the first to use cold treatment to improve the properties of metals. Indeed, legend has it that for years Swiss watchmakers have stored watch parts in high mountain caves for cold conditioning. A more moderate freeze, down to as low as -120 degrees F (attainable with dry ice and acetone), is used in the production of some metal parts.

The first person to develop a dry deep-cryogenic process (where the parts are chilled to liquid-nitrogen temperatures but don't touch the liquid) was Edward R. Busch, who in 1966 started—and still operates—Materials Improvement, Inc., in Hazel Park, Mich.

Today only a few facilities scattered across the country do dry deep-cryogenic processing. The best known, besides Applied Cryogenics and Materials Improvement, are Amcry Corp. in

Glendale, Calif., and 3X Kryogenics, Inc., in Addison, Ill.

The benefits

One reason companies—usually manufacturers—submit their tools for deep freezing is to increase the abrasion resistance, frequently of cutting edges or other high-wear surfaces. The success of the process depends partly on the tool itself. "Cryogenic processing will not turn poor alloys into superior ones, though it will improve them," Levine noted. "But superior alloys show the greatest improvement."

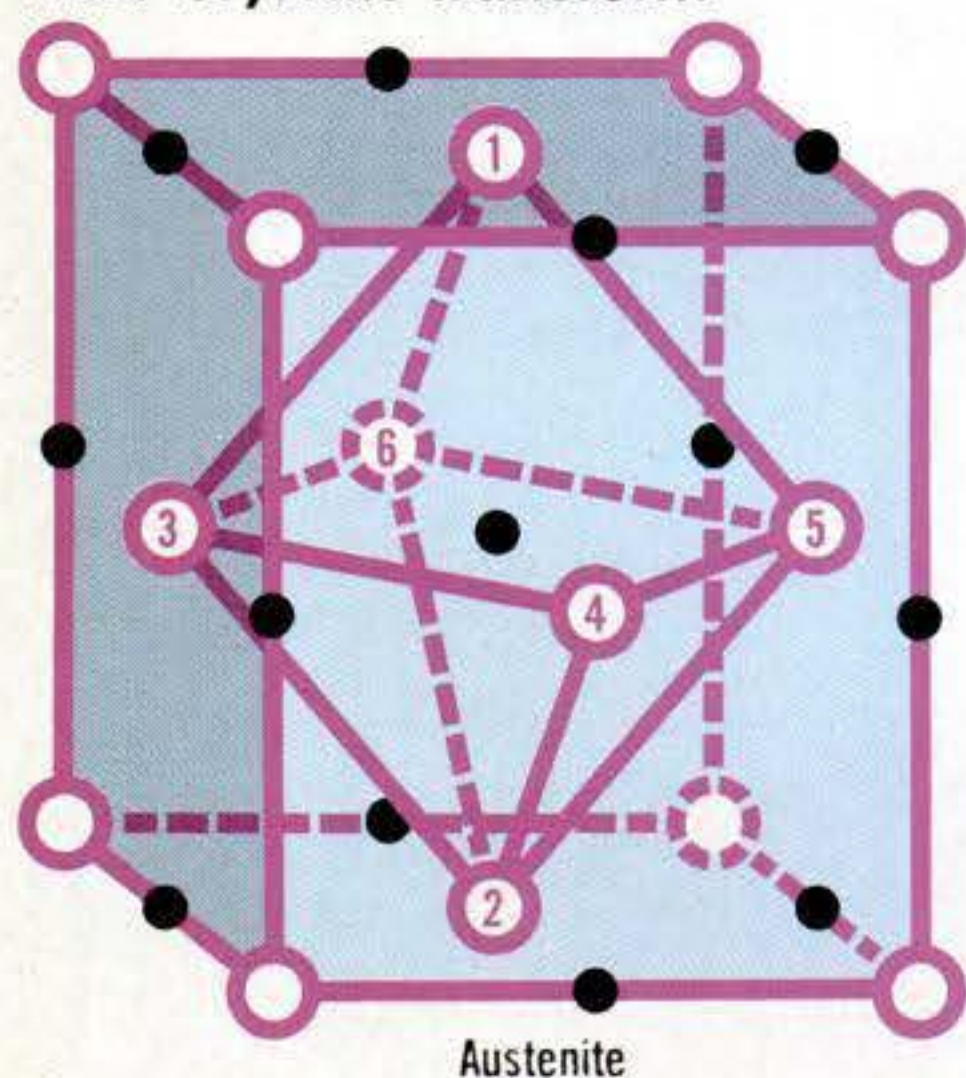
High-alloy tool steels have high reported success rates. Mixed results are reported with carbide parts.

Success also depends on what the tool is cutting. Freezing is particularly helpful when a tool has to cut hard metals—stainless steel and titanium, for example—or abrasive stuff such as sand castings or fiberglass.

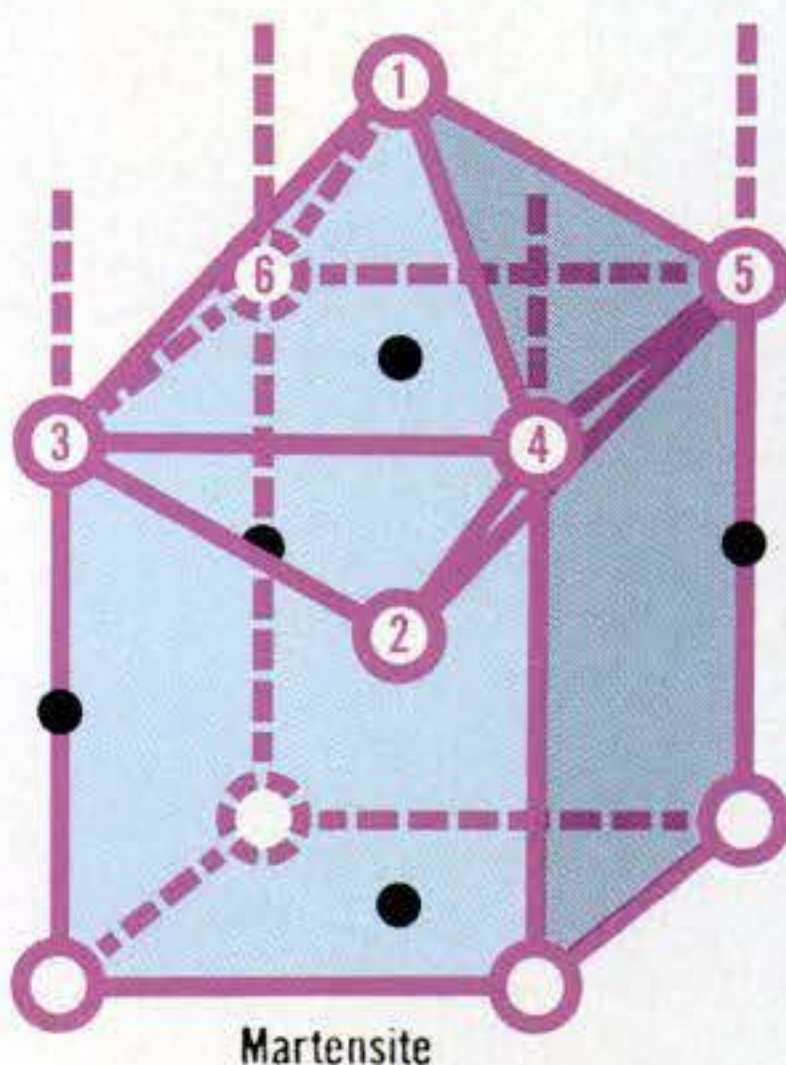
Freezing tools does not increase their hardness, tests show, nor does it make them more brittle.

"In eighty percent of the cases, we see an increase in the life of the part from two to five times," Levine reported. In most of the remaining twenty percent, we see no improvement." In a few, though, spectacular

How crystals transform



○ Iron atoms
● Possible locations for carbon atoms



DRAWINGS BY ELIOT BERGMAN

In austenite, a crystalline form of steel, each unit cell is a cubic structure with iron atoms at the corners and center of each face of the cube. These face-centered atoms, labeled 1—6, form an octahedron. Carbon atoms can occupy any of the sites indicated between iron atoms. Upon quenching from high temperature, austenite becomes martensite, a different crystalline form of steel. Cryogenic treatment can cause any austenite retained after heat treatment to transform to martensite.

A unit cell of the martensite crystal is not cubic but is slightly elongated. Iron atoms still occupy the corners, but those that were face-centered in the austenite cell (1—6) move as shown, leaving the No. 2 atom in the center of the cell rather than on one of the faces. The No. 1 iron atom occupies the center of the adjacent cell (indicated by dotted lines). Austenite crystals are ductile but soft; martensite crystals are hard but must be tempered to combat brittleness.

Freeze shop tools? Maybe not...

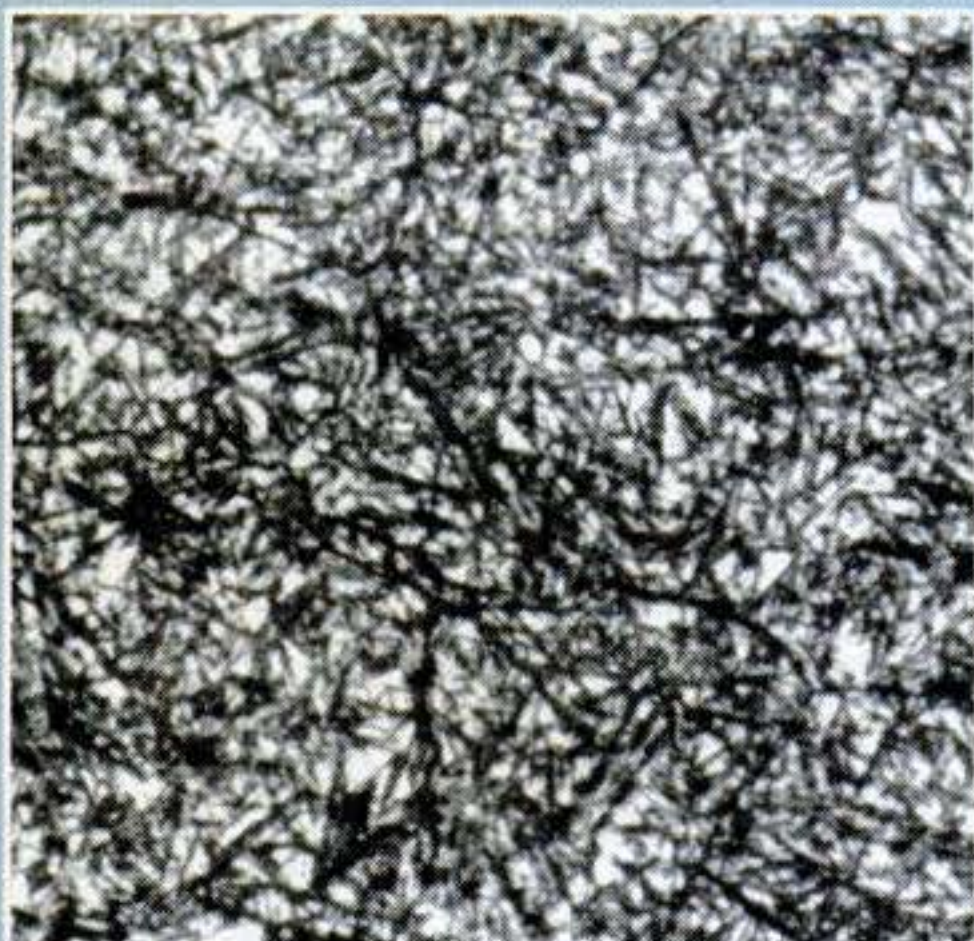
POPULAR SCIENCE wanted to find out whether cryogenically treating consumer tools would improve performance noticeably, and I was asked to run some tests. I purchased pairs of identical hole saws, circular-saw blades, router cutters, band-saw blades, metal-cutting sabre-saw blades, and two sets of twist-drills. I sent them to the editors, who coded them, sent one of each for deep freezing, then returned them all to me. I did not know which tools had been frozen.

I ran each pair under similar conditions, keeping feed rates as steady as possible, until one or both failed—or showed a real difference in performance.

Of the seven pairs of tools, the *untreated* examples came out the winner in five cases. When I reported my results to the editors in New York (by code only; I still didn't know which tools had been frozen), they asked me to try a couple of other tests, attempting to eliminate some of the shortcomings of the first tests.

One problem: The sample was too small—just one of each item. So I was asked to buy two dozen of the same high-speed steel drill bits. Another possible problem, suggested by Applied Cryogenics, was that the materials I had cut—particleboard, steel channel, mild steel plate—can cause galling. Cryogenic treatment can do nothing to keep a tool from gumming up, the company said.

So we chose stainless steel for the new drill test. The first two bits I tried turned out to be outstanding. After a couple of hours I called the editors and asked for the code num-



Black "needles" in the photomicrographs of tool steel (above) are martensite crystals; white background is retained austenite. After cryogenic treatment and tempering (right), retained austenite is transformed to a finer martensite matrix. Samples were magnified 400 times under a micro-



scope and photographed by metallurgical consultant Paul Nowich. The "before" sample was intentionally overheated in its heat treatment to yield enough retained austenite to be visible. Properly heat-treated tool steel would likely not have enough retained austenite to show up.

results are seen. According to Busch, the range of improvement reported by his clients has been 25 to 3,000 percent.

Reducing wear, even by modest amounts, can have a large effect on the economics of production. Not only do you need fewer tools, but you also reduce costly downtime. By specifying cryogenic processing for only four kinds of drills in its Palmdale, Calif.,

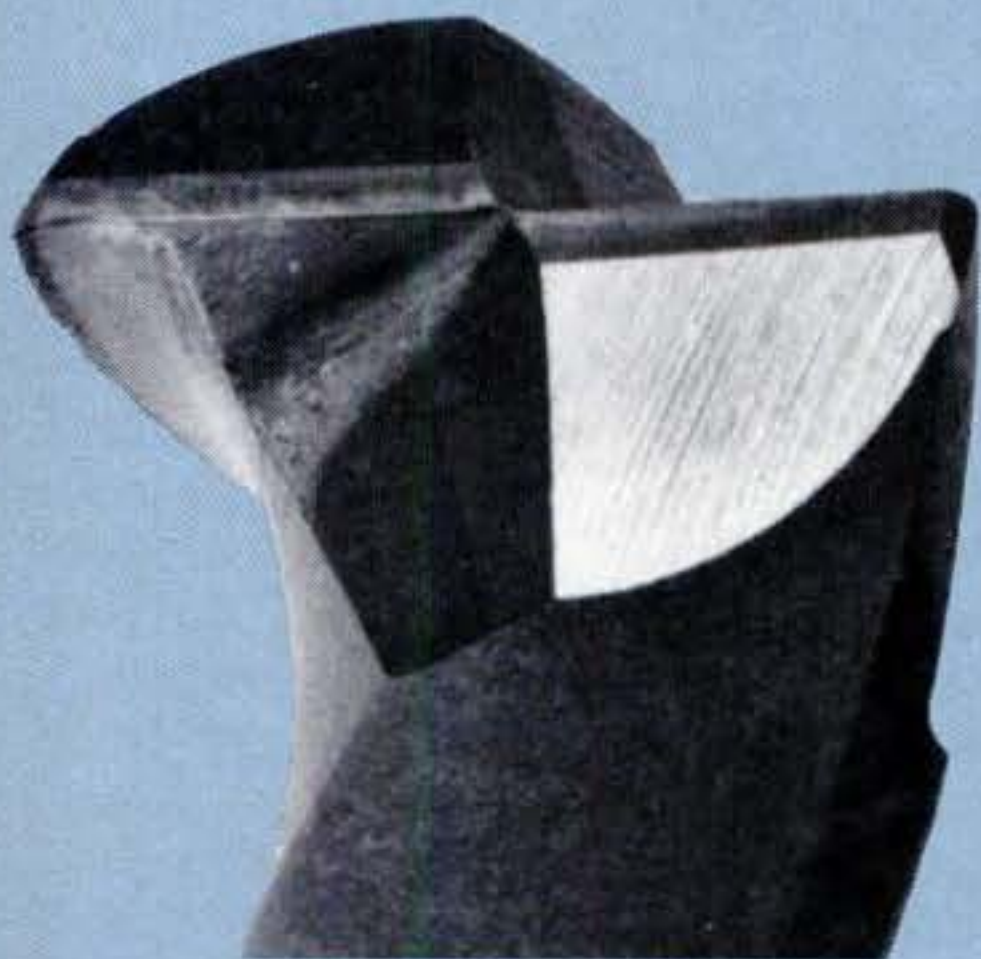
production plant, Jim Boldt of Northrop Corp. estimates his company will save \$350,000 annually.

Not all the praise for cryogenic processing comes from big industries. Parked in front of Applied Cryogenics's office the day I visited was a red Fiat X1/9. When the car was new, the owner kept grinding through the disc-brake rotors. So Applied Cryogenics froze them. Now the problem is solved,

I was told. "Our motto is, 'If it fits in the box, we'll freeze it,'" Levine joked.

Indeed, the company has frozen some bizarre items, some in which abrasive wear is not a concern, and some that aren't even metal—golf balls, for example. "One of our customers asked the golf pro at his club to hit a bucket of seemingly identical balls as far as possible. Half had been

[Continued on page 106]



The two high-speed steel end mills above were run on the same multi-spindle milling machine, cutting aluminum for armor plating. The one on the left, which had been frozen to -320°F



by Amcry Corp., was photographed after 10 hrs. of work. Its edge was still sharp and smooth. The untreated mill on the right was dull and chipped after only 4 hrs. of cutting.



Saw-chain teeth after PS test show unequal wear. Left tooth was not cryogenically treated; right tooth was. These were typical examples, but the difference was sometimes less dramatic.

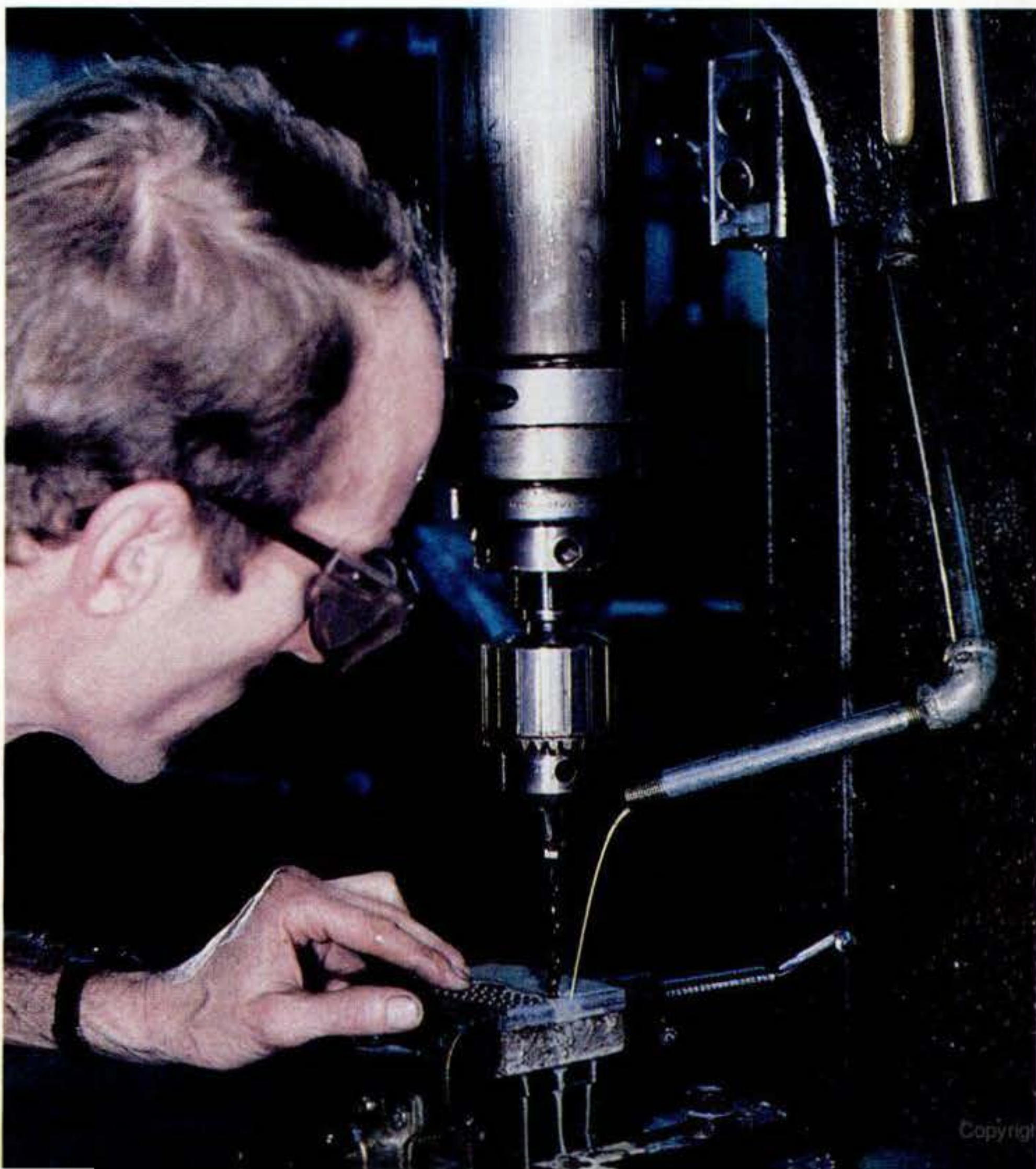
bers of three treated and three untreated drills: With 24 bits to test I would have drilled forever.

I drilled 160 holes with each of six bits in $\frac{25}{64}$ -in.-thick type-420 stainless steel on an industrial drill press (photo, right). Then I examined the cutting edges under a $10\times$ magnifier. Of the six, three seemed slightly less worn, but the differences were pretty judgmental. All could have drilled more holes, but I ran out of material. Of the three that seemed least worn, two turned out to be untreated and one treated.

Finally, I tested a saw chain. I bought one chain, which I split in half, and sent both halves off for coding and one half for treatment. I reassembled the chain and cut a huge pile of wood with my chain saw. Then I cut down six small trees, and used the saw chain to cut out the stumps.

By now the chain refused to cut. All of the teeth showed wear, but not equally so. This time, most of the teeth that showed the worst wear were untreated, and most that looked the best were treated. There was excellent correlation (photo above right).

But in most of my tests, cryogenic treatment didn't come out very well. Larger samples might have changed the picture. Jeffery Levine at Applied Cryogenics insists that cryogenic treatment could not have degraded the performance of these tools. Seemingly identical consumer tools can exhibit a lot of quality variation—too much, perhaps, to determine the effects of freezing.—Phil McCafferty



Loudspeakers designed

Most loudspeakers claim to be digital-ready, but are they really different from earlier models? A professional engineer explains why digital recordings demand better speaker performance, and how the latest designs satisfy the demands.

By **LEN FELDMAN**

KENT, ENGLAND

I followed Laury Fincham, director of engineering at KEF Electronics, Ltd., through a heavy steel door at the company's research center here in Maidstone, Kent. I expected to step into a reflection-free anechoic chamber—one of those eerie rooms filled with wedges of sound-absorbing material that are so quiet you can hear your heart beat. Instead, the walls were completely bare. Not only did the room lack soundproofing, it was positively reverberant.

Inside this room, KEF tests its new loudspeaker designs, using a technique called impulse measurement. The test wasn't possible before the invention of computers, and it wasn't necessary before the advent of digital recordings. Compact discs and digital audio tapes, with their increased capabilities, have forced loudspeaker designers to establish new parameters for speaker performance—parameters that don't require the unusual properties of an anechoic chamber designed to prevent sound reflections.

Performance characteristics such as accurate frequency response and high efficiency have always been important, but with digital signals they have become more so than ever before. Today's digital media capture a wider range of frequencies and a greater dynamic range—the difference between loud and soft passages—than do analog recordings. These capabilities make digital recordings sound more like live music, but only if the new generation of loudspeakers can reproduce the sounds accurately and duplicate musical peaks—especially loud bass passages—without distortion or audible vibration. I spoke with some of the top U.S. speaker designers to find out how they are addressing the new demands. And I traveled here to the southern coast of England to investigate two particularly innovative designs.

"In this era of digital recording, pro-

gram material with bass that extends all the way down to the lower limits of human hearing is easily stored on a CD," Fincham told me as we moved to the center of KEF's testing chamber. But measurements made in even the largest and most expensive of anechoic chambers are rarely accurate in the lowest octaves of sound—below 70 hertz. So in this new chamber, things are done differently.

Atop what looked like a flagpole stood a new KEF loudspeaker. A microphone, suspended from a boom, faced the speaker. "It's important to be able to make very accurate response measurements over the entire audio band," Fincham said. To make the measurements, brief electrical impulses—containing all the frequencies that must be analyzed—are fed into the speaker. The microphone samples the speaker's response to each sound burst before it can bounce off the walls, and sends the information to a computer that plots a frequency-response curve.

Tests done in this chamber revealed that deeper bass can cause excessive vibrations in speaker enclosures, according to Fincham. These vibrations move air, creating sound waves much like those intentionally created by the speaker drivers themselves. To cope with vibration, KEF's new model 107 and its older model 104/2 use twin coupled-cavity bass loading. Two bass drivers are coupled together by a non-ferrous alloy bar bolted rigidly between their magnet structures (see drawing). Normally, the drivers work together—in phase—to double the low-frequency output. However, any vibration produced by one driver will be out of phase with the other and is absorbed by the bar.

To help the speaker reproduce bass sounds, KEF has also added KUBE, for KEF Universal Bass Equalizer. "What low frequencies the speakers and enclosures aren't able to produce by themselves are accomplished by the electronic equalization," said Fincham.

Normally, a crossover network—a speaker's electronic filters—performs three functions: It divides the frequencies between the different driver units (woofer, mid-range, and tweeter); ensures an appropriate load match for the amplifier; and provides some equalization to shape the overall response of the system.

In KEF's new system, a conventional passive crossover network performs the first two functions. The third—equalization—is done by KUBE, which is connected between the pre-amplifier and amplifier or, in the case of integrated amplifier-receivers, at one of the output/input pairs normally reserved for a tape deck.

For digital music to sound natural, the speaker system must also provide good stereo imaging—left and right speakers must reproduce sounds similarly to give the feeling that all of the instruments are evenly positioned across the "sound stage" in front of you. To improve imaging, KEF measures the characteristics of every speaker element it makes and stores the results on computer tapes. The company then matches similar drivers in pairs so that the left and right speakers are as close in performance to each other as possible.

Honeycombs and more

In the town of Worthing, a few miles from KEF's lab, B&W Loudspeakers Ltd. is also striving for better imaging and reduced vibration, but with a completely different design. John Bowers, the head of the firm and an acoustic design engineer, played some loud orchestral music through a speaker that his firm designed 10 years ago. He placed my hand on the side of the cabinet. "Well?" he asked. I could feel the box vibrate heavily with every musical beat.

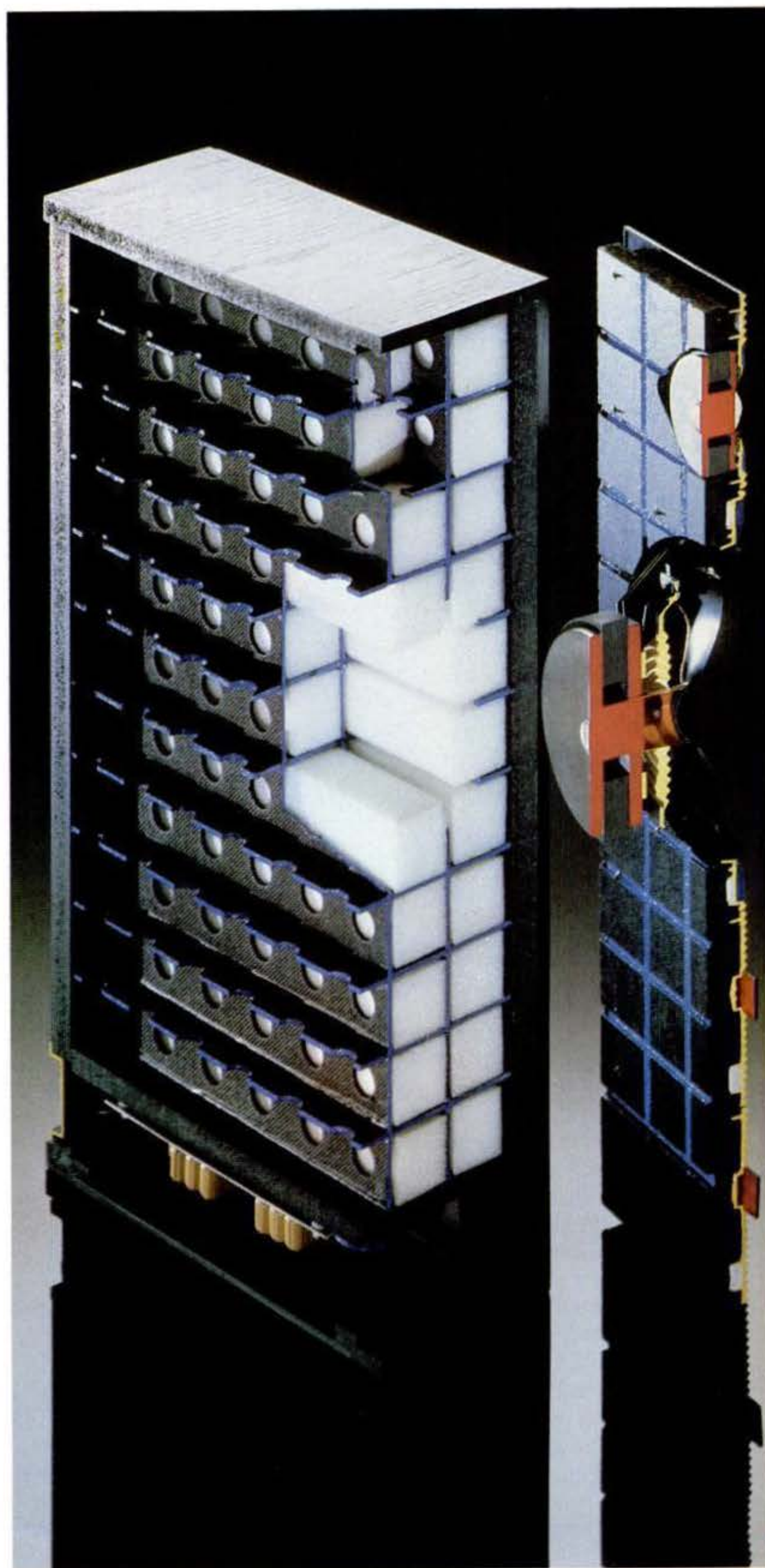
Then Bowers showed me B&W's new series of Matrix digital monitor speakers, designed to eliminate cabinet vibration. Each speaker uses a

Continued

for digital sound



Two ways to reduce cabinet vibration: A nonferrous bar joins KEF's twin bass drivers (left), absorbing out-of-phase vi-



brations. B&W speaker (right) contains a foam-filled matrix that stiffens the cabinet, preventing motion.



Toward a "cabinetless" speaker

Celestion International's new System 6000 replaces low-frequency speaker boxes with bulging "dipoles." The intent is to eliminate cabinet vibrations so the sound will be identical to that produced by a live musician. The \$5,000 system includes a pair of SL600 upper-range units and a crossover with active equalizer. It requires a second stereo amplifier.

honeycomb-like structure that slides into a cabinet with grooved inner walls (see photo). Each cell of the matrix is filled with acoustic foam. Tests revealed that the matrix stiffens the box, making it more inert and correcting the problem of vibration.

Reducing cabinet vibration improves low-frequency performance, but a digital speaker must also reproduce high-frequency sounds at the correct amplitude relative to other pitches. "Recently, we played some CD material using a prototype speaker design we were working on," Bowers recalled. "We found that the sound of the string instruments was hard and unpleasant. Later, we discovered that the problem was caused by a rise of only 1.5 decibels in the tweeter response at around fourteen kilohertz." Bowers said an analog recording of the same music sounded acceptable because it had

not captured the high-frequency peak.

Analog recordings also suppress high-volume peaks. "The dynamic range of a CD is at least ten decibels greater than that of an analog disc," Bowers told me. "All other factors being equal, it would seem that the most practical way to deal with this greater range is to increase speaker sensitivity and power handling."

To handle a 10-decibel increase in dynamic range solely by increasing amplifier power, you'd need an amplifier that's 10 times more powerful. So it makes more sense to increase dynamic range by improving the speaker's sensitivity—how efficiently it converts electrical power into acoustical power. A redesigned crossover network and drivers in the Matrix 3, the largest of B&W's three new designs, allow it to handle amplifier power of up to 200 watts. And its sen-

sitivity is rated at a sound-pressure level of 90 decibels, measured at a distance of one meter in front of the speaker for 2.83 volts of input.

The same improvements have been made by KEF in the efficiency and power handling of its speakers. The model 107 has higher sensitivity than earlier KEF speakers of similar size—it's able to create 90 decibels with 2.83 volts applied—and handles up to a whopping 300 watts of power.

American companies like Ohm Acoustics Corp. and JBL Inc. have always been known for manufacturing high-efficiency speakers, but digital audio is pushing them to develop even better designs. Ohm has incorporated filters in the crossover network of its speakers that boost low-frequency output. These passive filters accomplish the same thing as KEF's KUBE.

Ohm is also using new materials to improve performance. "Because digital-ready systems must be efficient," says Ohm President John Strohbeen, "they require much heavier magnet structures, lighter cones, and more rugged construction of all the elements that make up a loudspeaker system."

Ohm's new 3XO system handles 200 watts of power on a continuous basis and can take short-term 300-watt peaks safely. "The 3XO creates four to six decibels more sound-pressure level for a given amount of power than did the earlier Ohm Walsh designs," claims Strohbeen.

Like Ohm, JBL is developing new materials. "New JBL speakers use titanium in the construction of tweeters," says John Eargle, an acoustic designer and consultant to JBL. The metallic element is harder than steel, but half the weight. Titanium foil $\frac{1}{5,000}$ inch thick is deposited on a ribbed tweeter. The ribbing and titanium make the tweeter rigid and thus more responsive to the high-frequency peaks that are found on compact discs. The company also laminates mid- and low-frequency drivers in units such as the JBL630, JBL830, and JBL940 with a plastic material for extra stiffness.

Although all of these changes in speaker designs are a plus for digital systems, they are a boon to analog sources, too. For that reason, the changes seem to be taken in stride by the speaker makers. "They are more evolutionary than revolutionary," says Eargle. Perhaps, but whatever the reason, it's clear that the final step to high-quality digital sound—the speaker system—has fallen into place. **ES**

B&W Loudspeakers (America), Box 653, Buffalo NY 14240
 Celestion Industries, Box 521, Holliston MA 01746
 JBL Inc., 8500 Balboa Blvd., Northridge CA 91329
 KEF Electronics of America, 14120-K Sullyfield Cir.,
 Chantilly VA 22021
 Ohm Acoustics Corp., 241 Taaffe Pl., Brooklyn NY 11205

Smart circuits revolutionize auto wiring

A technological revolution is developing beneath the sheet metal of tomorrow's cars. Miles of copper wiring and labyrinthine wiring harnesses are being replaced by simplified wiring—some of which will not be wire at all, but fiber optics—along with scores of microchips in buttons, switches, motors, and other elements of the new control circuits being developed. The new system will reduce weight, cost, and complexity; increase reliability dramatically; and change the way you interact with your car.

By **DAN McCOSH**
Detroit Editor

One of the engineers responsible for the concept car on display in the lobby of General Motors Corp.'s headquarters strolled up as I was looking it over. The car picked the engineer from the crowd of onlookers like a dog recognizing its master. As the engineer approached the door, the instrument panel lit up, the door opened, and the steering wheel swung away to make room for him.

It was an eerie demonstration of automotive extrasensory perception. But it turned out to be just one capability engineers are hoping to achieve with the next generation of on-board automotive electronics: They foresee an era of "smart power," when most of the car's basic systems—ranging from transmissions to window lifters—become electronic-mechanical hybrids and begin to talk—and even listen—to each other.

Of course, the car wasn't actually responding to its master. After I had examined the Chevrolet Express show car and climbed out from under its bubble top, Ron Jameson, a Chevy development engineer, explained the trick. As we walked away—and the car closed itself up and shut down behind us—Jameson pulled a matchbook-size device from his pocket.

Here, he said, is what happened: The device in his pocket was a tiny low-powered transmitter. When he got to within about five feet of the car, a receiver in the car was able to detect the transmitter's weak signal and set off the sequence of events I described, which had been programmed into the car's master computer. Then as we walked away from the car, the receiver lost the signal, triggering the close-down sequence, again controlled by the master computer.

Helping accomplish the door-opening stunt was a revolution in automotive wiring, which has evolved from a simple power-carrying circuit to a kind of communications link carrying something akin to intelligence—as demonstrated by the empathy the show car in GM's lobby had for its engineer.

Charm bracelet

All of the electrical components of the experimental Chevy, including actuating motors, steering-column adjustment, door locks, and door openers, were connected like charms on a bracelet by a continuous information-carrying wire. This information loop carried commands from conventional cockpit controls along the circuit to the various accessories. Tapping into this information circuit with the radio transmitter was easy, and allowed the transmitter to send digitized orders to any device along the line, including

the sequence of commands that made the car greet its master. Multiplexing, as engineers have named this system of information distribution, had turned the experimental car's wiring into a kind of central nervous system.

Although multiplexing for cars is still in the developmental stage, today's auto engineers have high hopes it will solve a variety of problems related to making on-board electronics more reliable, cheaper, and "smarter." Eventually, they theorize, multiplexing will allow centralized computers to issue orders directly to a new generation of electronically controlled accessories—smart motors that could eventually replace many of today's hydraulically controlled systems, such as power steering and automatic transmissions, and greatly simplify electrical accessories such as seat controls and power windows.

Say, for example, you want to lower the right rear window in a car with multiplexing. You press the proper button on the armrest. The microprocessor beneath the button generates a unique code and sends it into a single universal circuit. Every unit connected to the circuit receives the signal, but they all ignore it. Only a central computer recognizes and acts on it.

The computer interprets the signal and understands that you want the

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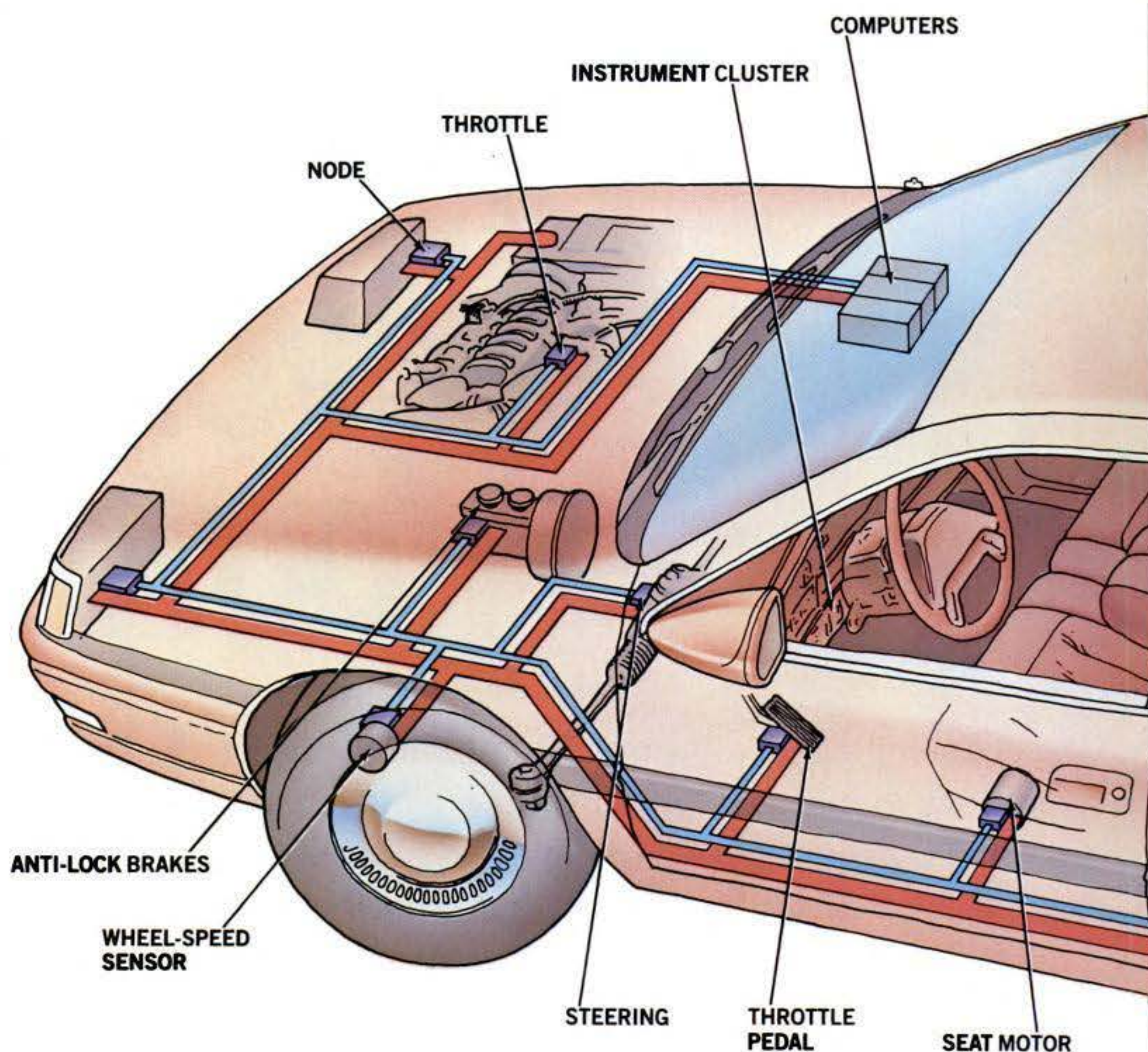
right rear window lowered. It generates a signal and puts it on the common circuit. The microprocessor attached to the right-rear-window motor—along with all other microprocessors—receives the signal. But it alone recognizes that the signal is addressed to it, so it does what has been requested: It switches on battery power to the motor and lowers the window.

Why go to so much trouble to open a window? First, such an approach drastically reduces the number of circuits through the car, which reduces weight, complexity, and cost. Second, it increases reliability: There are no longer hundreds of individual wires that can cause trouble. And third, it gives enormously increased flexibility. For example, you can program the computer to automatically raise all the windows when you lock the car. Or an outside sensor could close the windows if it detected rain.

As revolutionary as it may sound, multiplexing is difficult for me to get excited about. A car's electrical system is, after all, nearly invisible, buried behind panels and running through out-of-the-way crannies in the body and chassis. Out of sight, out of mind—barring the occasional gremlin that turns on your windshield wipers when you attempt to blow the horn. Yet year after year, as I've watched computers take over ignition control, fuel systems, and now transmissions and even suspension systems, it's been obvious that all these new devices are straining the capacity of an electrical system that hasn't changed significantly since the 1960s, when alternators displaced the old-style generator. Perhaps I've been selling wiring short. To get a better perspective, I went to Ford Motor Company's Diversified Products Technical Center lab, where engineers had dissected the wiring of a full-size Lincoln Town Car.

Like a novice surgeon's first view of an appendectomy, looking at a car's wiring system is something of a shock. Some 55 individual pieces of heavy-gauge wire snake from a single car door, emerging as a broomstick-thick bundle that branches like the Amazon delta into the farthest reaches of the instrument panel. If only from the sheer number of wires and connections, it was easy to see why today's computer-laden automobile seems on the verge of a nervous breakdown.

Next to the intimidating tangle was an example of what even a simple multiplexed wiring system would look like: On the second car, each electrical device was capped by a discrete "black box." Connecting the boxes, and replacing most of the labyrinthine wiring harness, was a simple pair of



DRAWINGS BY EUGENE THOMPSON

twisted wires. Where before a thick bundle of wires had run from the door—where the lock, window lifter, and seat adjuster each demanded a power-carrying switch—a thin twisted pair of wires carried the essential command signals for all these devices.

How was this elegant simplicity achieved?

Ford's David J. Patterson, manager of advanced vehicle controls, told me that a small computer located inside the door responded to signals from each switch on the door panel. The door-mounted computer, called a node, responded to the driver's command by sending a coded digital signal over a pair of twisted wires to a second "receiver" computer that activated the accessory motor.

But Patterson was quick to point out that the apparent simplicity of multiplexed wiring is deceptive. "In a way, we are trading the complexity of the wiring bundle for the complexity of the microelectronics at each end," he said.

To illustrate his point, Patterson hefted the handbook-size computer in the prototype's door panel that sent the computerized signals to the communications wire. If the computer remained in its experimental size, the whole exercise would be pointless. But then he handed me a ceramic chip half

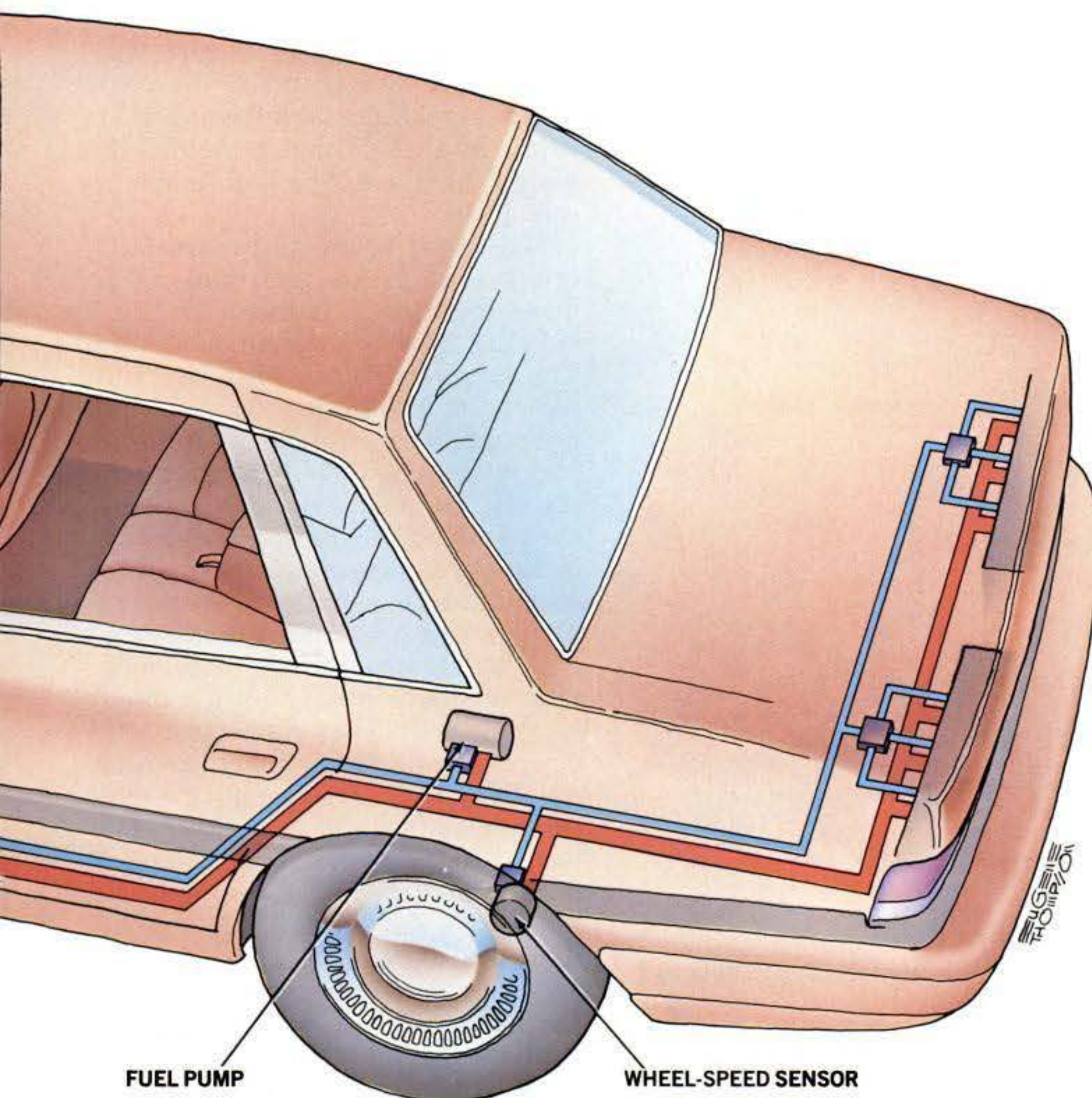
the size of a stick of gum. "This is what we did to see what a production chip would look like," he told me.

The crude setup in Ford's laboratory illustrated the elements of a basic multiplexing system: At the driver's finger tips were touch-pad semiconductor "switches" that signaled one computer of a command. The computer in turn generated a coded signal that went over a communicating wire or bus. The signal was received by a second computer, which activated a load-carrying relay or high-amperage semiconductor bank. Current then flowed to make the control motor work.

That basic outline is followed in Cadillac's new \$55,000 Allanté sports car, which uses a data bus to control its exterior lights. (Cadillac claims it's the first production multiplexed system.) The driver's touch pad is actually an input signal module (ISM) that activates a body control module—the "sending" computer. Receiving the signals are a bank of nine output signal modules (OSMs) that control current-carrying relays for each exterior lamp.

Each OSM incorporates a "status" function that tells the body-control computer whether the lamp is operating. If it isn't, various "failure" strategies do things such as light up outside marker lamps if a headlight burns out.

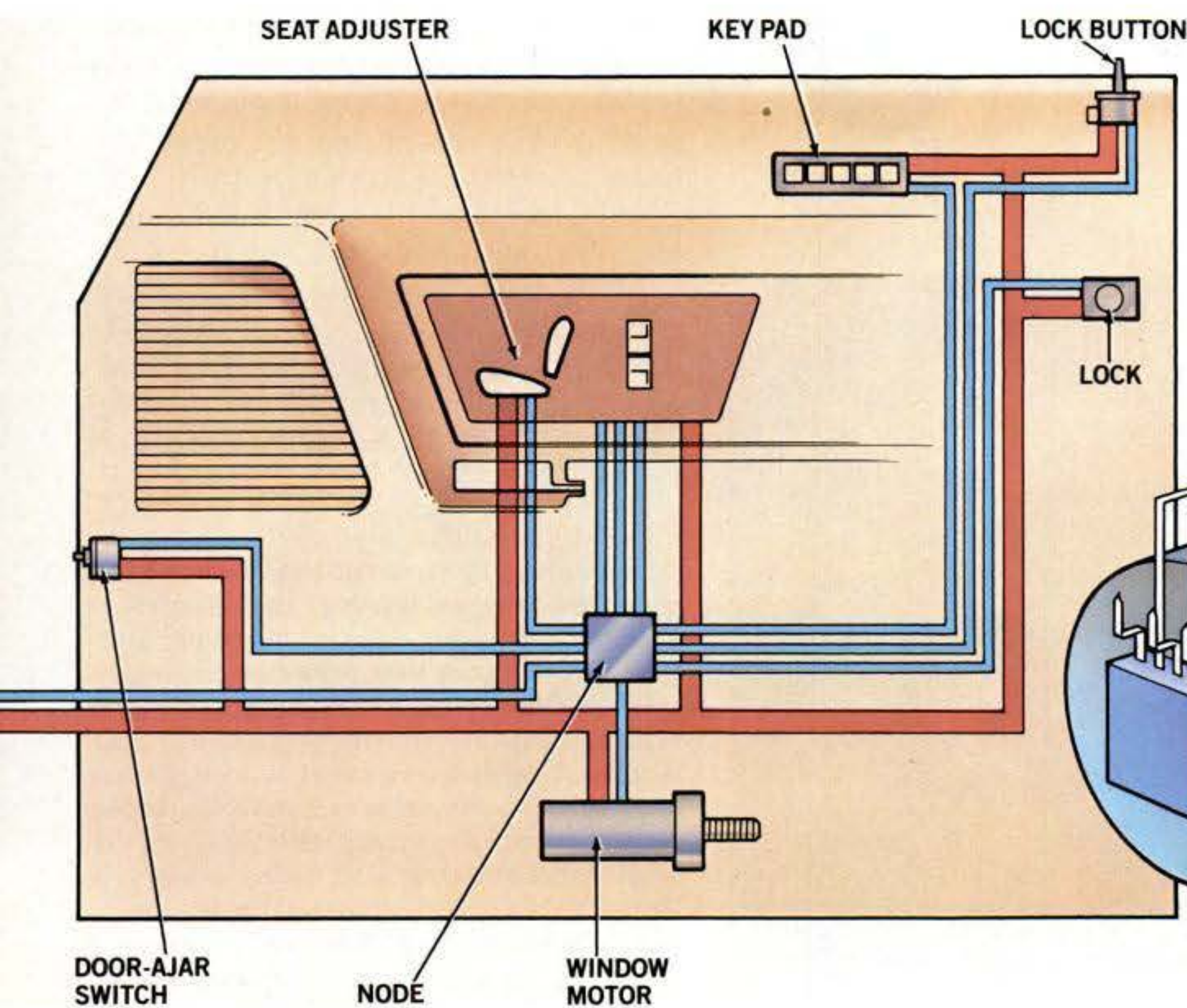
Ford's new Lincoln Continental will



FUEL PUMP

WHEEL-SPEED SENSOR

POWER BUS
SIGNAL CIRCUIT



SEAT ADJUSTER

KEY PAD

LOCK BUTTON

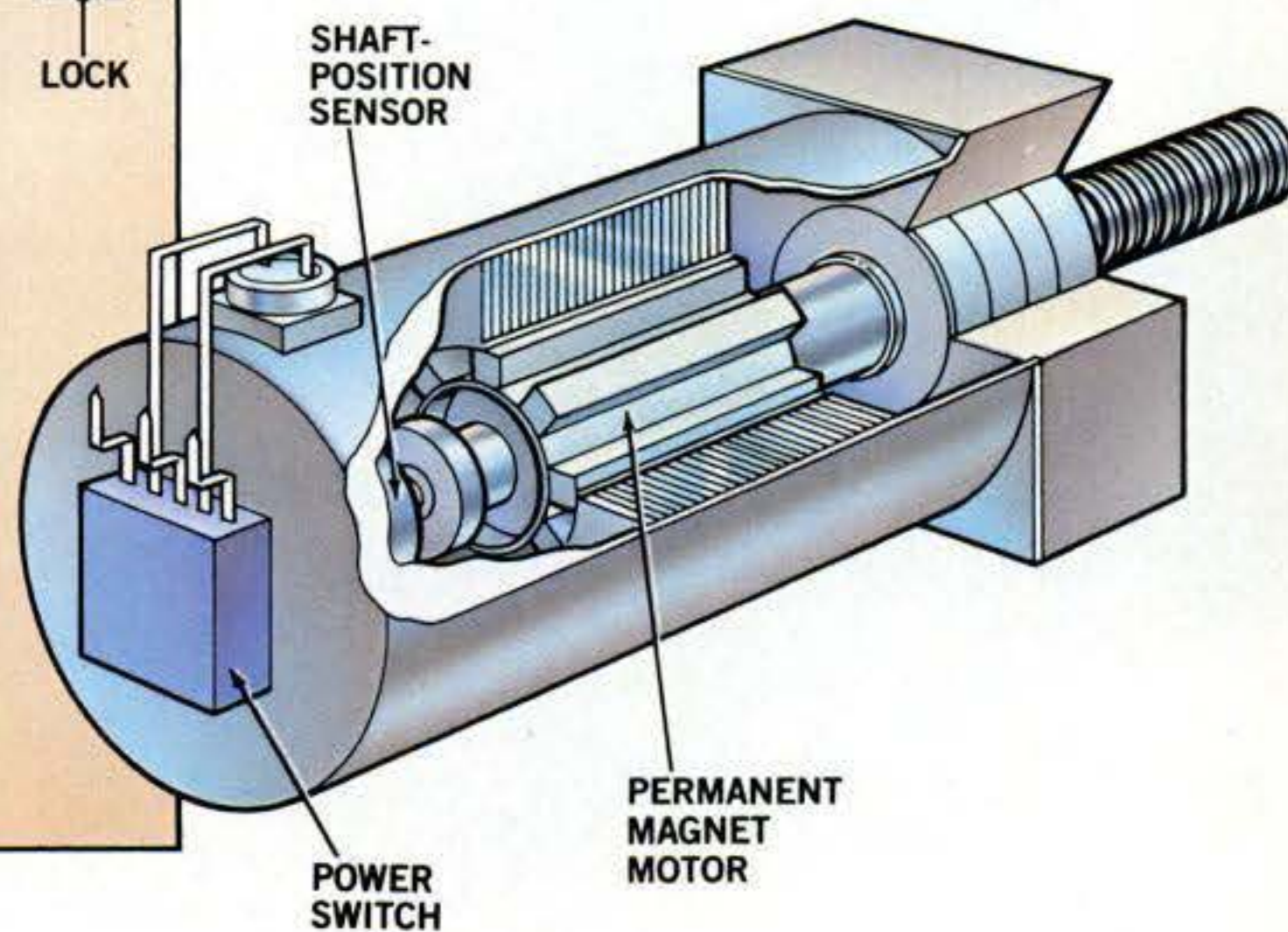
LOCK

DOOR-AJAR SWITCH

NODE

WINDOW MOTOR

DOOR DETAIL



SHAFT-POSITION SENSOR

POWER SWITCH

PERMANENT MAGNET MOTOR

MOTOR DETAIL

feature yet another step forward for multiplexing. Receiving the signals from the body-control computer is the first production application of a "smart power" switch, a high-amperage semiconductor that responds directly to computer commands and incorporates simplified logic ["Now: Power and Logic on One IC Chip—the Control Revolution," Nov. '85].

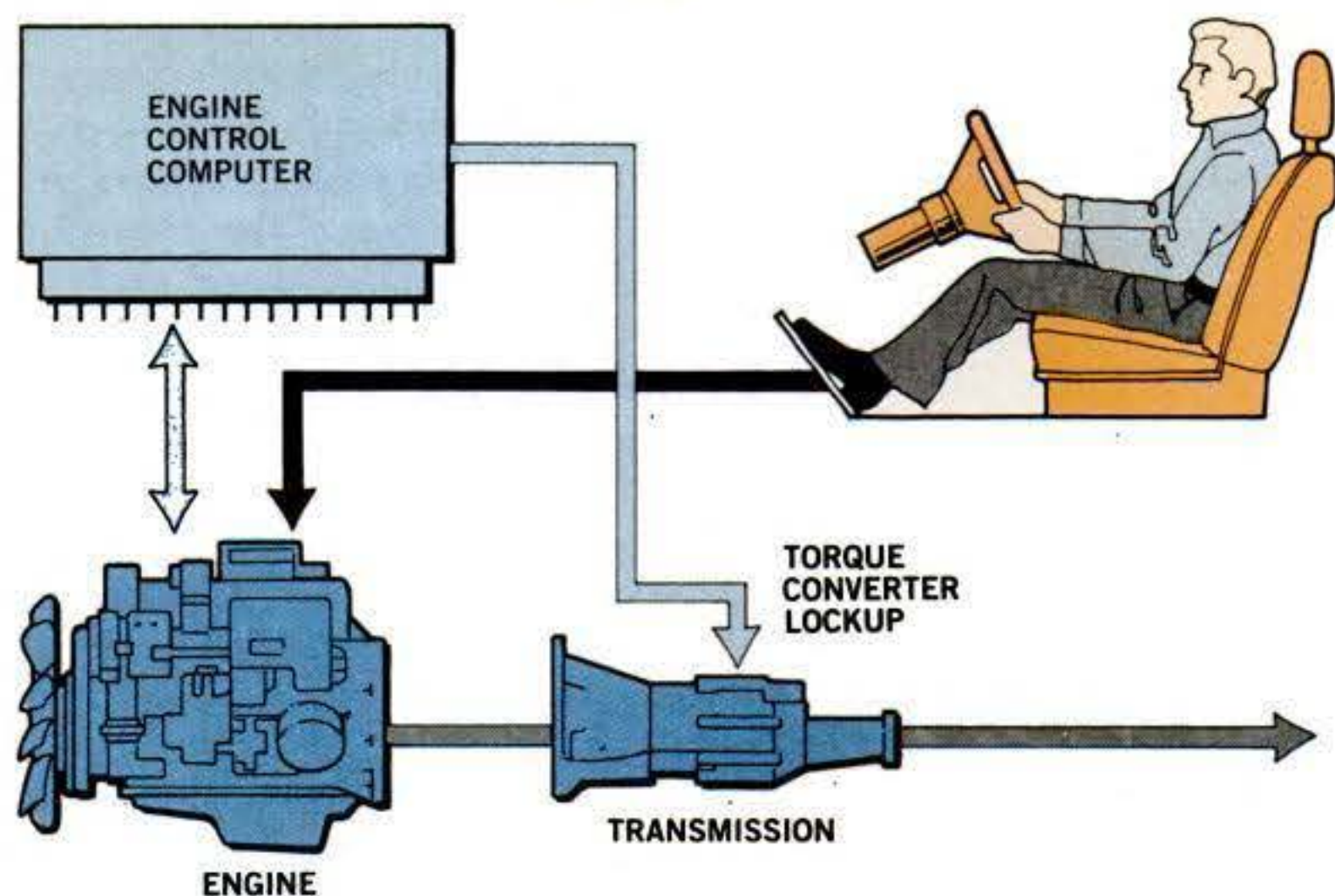
The Ford smart power chip will be used to control a shock valving system that automatically adjusts shock rate to speed and road conditions. It's similar in principle to an electrical system used on the 1987 Thunderbird, but uses a full multiplexing system to do the control work.

These early steps are likely to be followed quickly by wider application of multiplexing. The Society of Automotive Engineers is moving quickly toward adopting technical standards that should make it easier for parts manufacturers to churn out basic components in volume, with some assurance they will work on all cars on the road—an important step in reducing the cost.

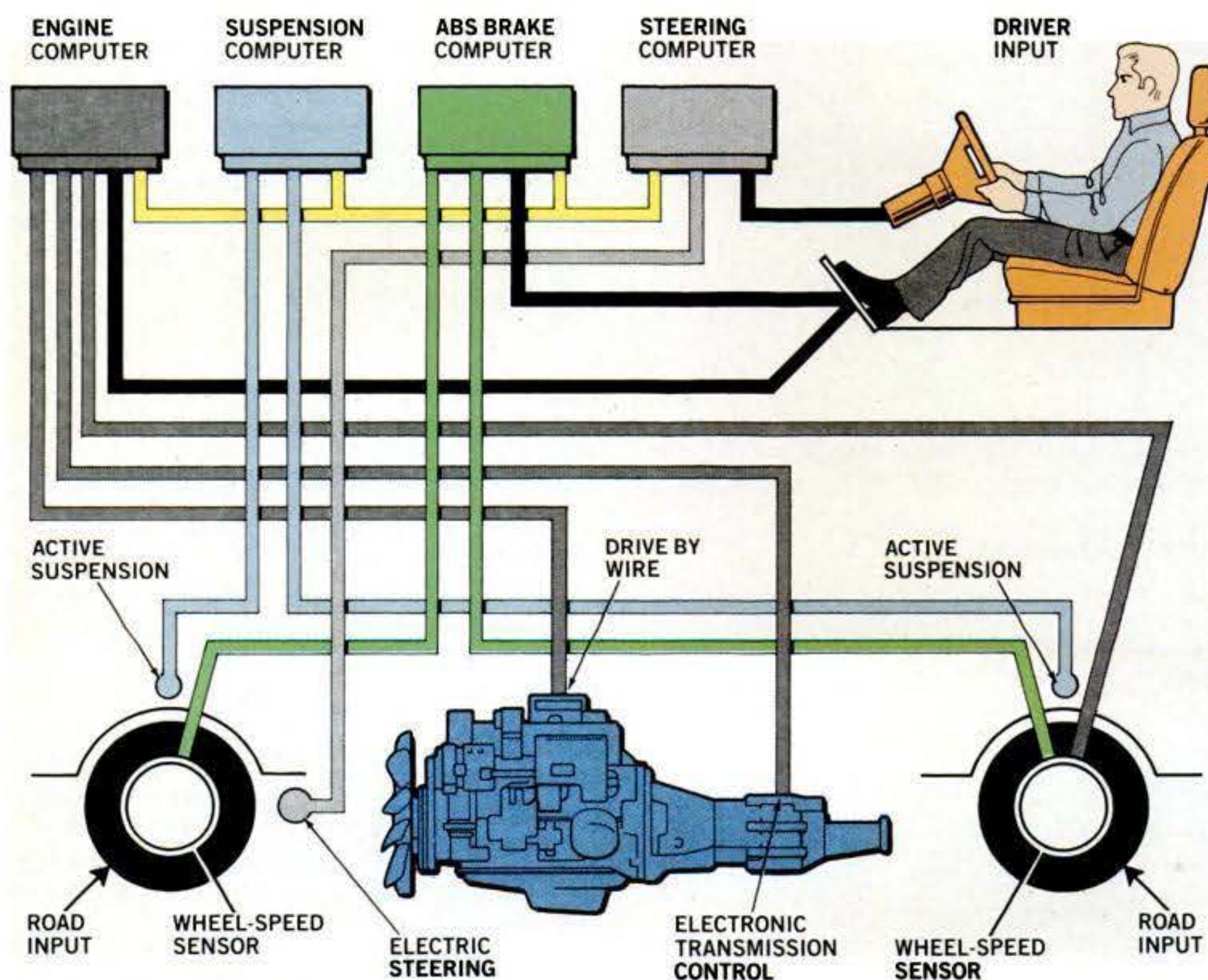
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Multiplexing would replace the miles of wiring in a typical luxury car with a pair of wires carrying digital instructions, plus a power bus (above left). Small computers, called nodes, might route signals to and from individual switches and components, each of which would incorporate a solid-state power switch. Smart motors like the one shown below would turn themselves on and off in response to the digital signal. They would also signal the computer that they were operating, and would protect themselves from shorts or overloads.

STAGE 1



STAGE 2



DRAWINGS BY EUGENE THOMPSON

High-amperage smart power chips, being developed by several companies for automotive use, are expected to quickly replace many of the mechanical switches currently in use. These units work by paralleling hundreds of low-amperage semiconductor elements in a single chip, a method that allows them to act as high-amperage computers.

The smart power chips have attributes that make multiplexing far more interesting than its ability to simplify a wiring diagram, however. The simplified logic in the new chips has the ability to directly respond to pre-programmed overloads—for example, automatically shutting off the chip if a short or a current surge develops, then reactivating it. It's an important feature to engineers, who normally expect such brief episodes to fry the current generation of microprocessors.

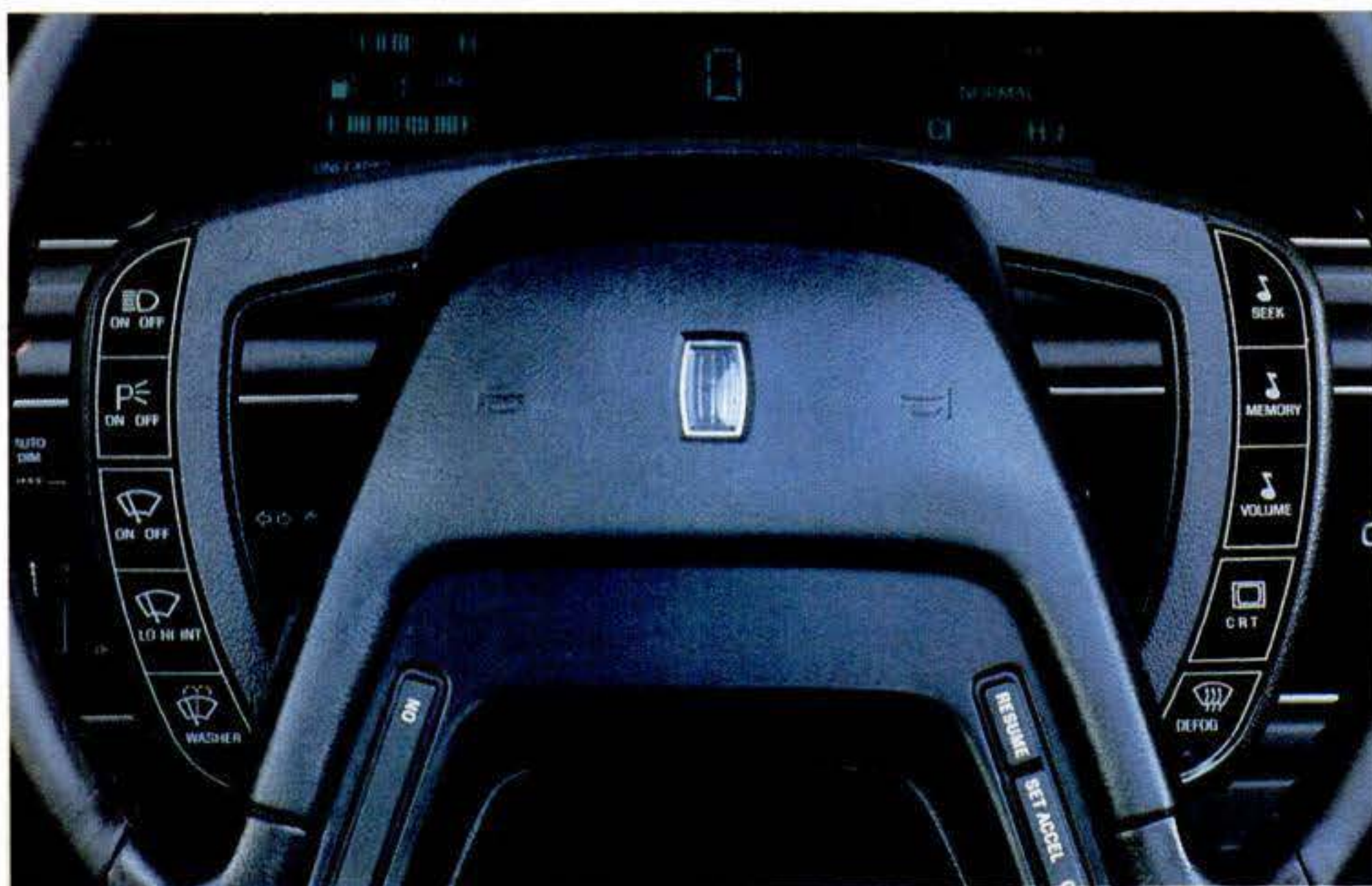
"In our system, the control computer is connected directly by a current-carrying wire that connects it to a device it controls," said Ford's Patterson. "Any time someone puts a screw through the wire or grounds that device, it doesn't work anymore. The device is destroyed. The customer has to go to a dealership and have the module replaced.

"If this were a smart power device," Patterson continued, "it would sense that the current was more than it could handle and shut itself off. Every once in a while it would try again, to see if the condition still existed, and then shut itself off again if necessary, protecting the circuit."

Once the basic multiplexing system is in place, expansion will be inevitable. GM is already testing a half-dozen prototype cars with a multiplexed door system that integrates six electrical functions onto a single-wire link. Alfa Romeo, Inc., has demonstrated a multiplexed modular instrument panel.

Aside from reducing wiring complexity and adding fail-safe capability, engineers are interested in how multiplexing will simplify car produc-

[Continued on page 112]



Although it is an intimidating-looking maze of copper wiring, the electrical system in today's cars is relatively simple. But as more computer systems are added, these Stage 1 designs (top left) will become increasingly complex. Individual computers must not only control their own subsystems but must communicate among themselves as well. Multiplexing will be necessary if Stage 2 designs (upper left) are to succeed. Multiplexing then opens up still further possibilities, such as the fingertip controls on the wheel of this United Technologies project car (left).

Stealth outboard

Passing unnoticed is key to military rescue, assault, and reconnaissance work. A quiet, drown-proof motor will help boat crews on hush-hush missions.

By BILL McKEOWN

Required: A machine that will survive seven days' immersion in salt water 400 feet deep. When brought to the surface, it will be tilted upward to drain water from the intake and exhaust manifolds. The cylinders will then be purged of water with a few pulls of the starter rope. After a few more tugs, the device must spring to life—quietly.

These paraphrased U.S. Navy specifications describe the military amphibious reconnaissance system (MARS) outboard motors now being built by Outboard Marine Corp. The Navy's Coastal Systems Center in Florida doesn't want to discuss the contemplated missions, but reports have it that the motor can be pre-mounted on an inflatable boat and launched through the torpedo tube of a submerged submarine. Alternatively, the rig could be dropped by parachute from an aircraft, along with an assault or rescue crew. Fuel is held in four remote-tank bladders of six gallons each. A small landing craft carrying seven men and their equipment at speeds of up to 30 mph would have a range of 20 miles or more. Increased range would be possible by towing a second inflatable boat carrying extra pods of fuel; thus amphibious teams could make undetected trips to shore from far out at sea.

The 35-horsepower MARS engine is actually a close cousin to a standard two-cylinder two-stroke outboard. There are no special valves to keep water from getting in, but indentations in the sides of the pistons help water escape when the cylinders are purged. The power head is shrouded with a sound-deadening jacket that reduces engine noise substantially from the level an unmuzzled version would emit. As in standard outboards, the ignition system is potted in plastic to seal out moisture. "Ninety percent of the features are the same as those of our standard pleasure-boat outboards," says Bob Gerling, director of special services for OMC, the maker of Evinrude and Johnson outboards. The company will be delivering several hundred MARS motors to the U.S. and South Korean navies; no commercial versions are planned.

PS



BEFORE

REACH FOR THE SUN



With a north-facing living room and low unfinished attic, this two-bedroom ranch was dreary and cramped—and there was no room for expansion. The owner and his father raised the roof to create a vaulted second-level living space and installed south-facing skylights and windows, transforming the house into cheerful, airy living quarters. Whether or not you want to tackle such a major job, you'll find ideas you may be able to adapt to your own home-improvement projects.

By **TIMOTHY O. BAKKE**

Photos by Greg Sharko

Wielding my utility knife, I had just cut through the joint where the stairwell wall meets the living-room ceiling. I stood on my ladder, listening.

"This one's a four-footer."

My dad's voice came from somewhere above me on the other side of the ceiling. I measured four feet from the wall and cut a parallel line in the ceiling four feet long, then another line straight back to the wall. With some gentle persuasion from above, the four-foot square of gypsum board popped loose along its joint lines, and I pulled it free.

With only this small section of ceiling gone, the bleak living room brightened as light flooded in from the roof windows. In a couple of hours my father and I had peeled the rest of the ceiling and removed the joists. Blinking in the sunlight with the ceiling gone, I felt like Lemuel Gulliver... as though a colossal Brobdingnagian had lifted the lid of the dark little box in which I lived.

With the removal of the living-room

ceiling, the project my father and I had started in late 1985 was nearing completion. The structural construction involved in raising the roof of my two-bedroom ranch was detailed in the October 1986 issue of *POPULAR SCIENCE*. This installment shows how, with the help of my father and other relatives and friends, I finished the interior. I used some interesting new products in the renovation, and you'll find novel tips you might be able to adapt to your own projects. Construction of the bath and various built-ins, including the bookcase and a desk, will be covered in a third, and final, article.

Dual goals

I had two ends in mind when I planned this project. One was gaining extra room; the other was letting in more light. They both were accomplished by creating a vaulted living space, using south-facing glass, and eliminating the existing living-room ceiling. Although I had to sacrifice the area directly above the living room, I gained a large master bedroom and bath, office nook, 4-by-16-foot storage closet, and 13-by-18-foot den with a wood-burning stove and bookcase (see photos and drawings on the next pages). After completing the outside of the addition and hooking up with the plumbing and heating systems, my first job was to insulate.

I wanted the most insulation I could get in the walls with the least amount of wasted interior space, so I used 3½-inch Owens-Corning fiberglass

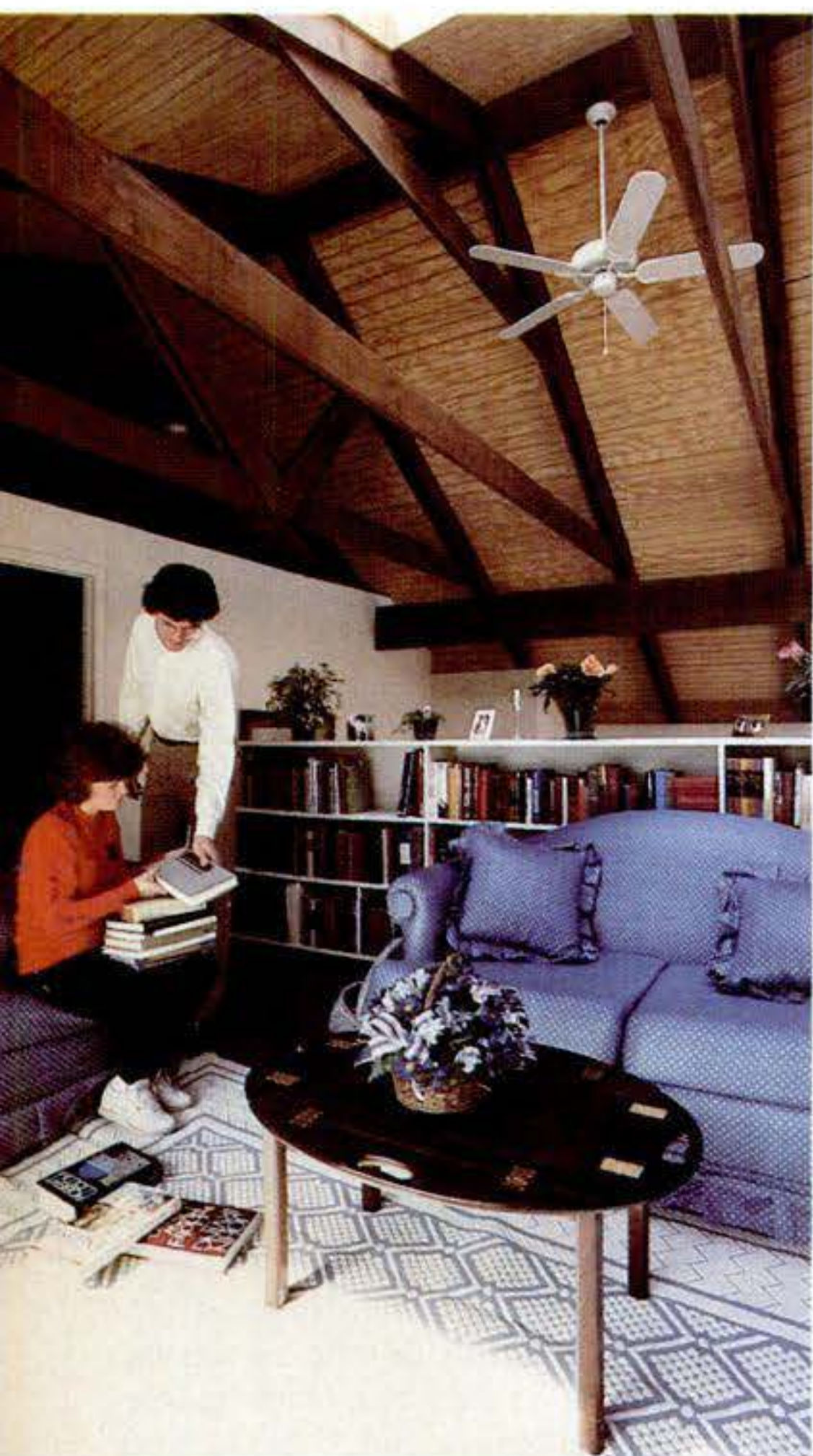
batts between the studs with an extra ½ inch of Energy Shield rigid polyisocyanurate insulation on the interior—for an insulating value of more than R-15. (Three inches of Owens-Corning Energy Shield insulation had gone into the roof when I first built it, for about R-24.) After installing the foil-covered insulating panels—and before putting up the wallboard—I would seal the joints with plastic tape to maintain the vapor barrier. But before I could install the panels, I had to put in the wiring.

The electrical work was one of only two aspects of the job for which I hired a contractor (the other was extending the heating system): Complicated wiring can get tricky; it can also be dangerous if it's done incorrectly. And complicated it was, partly because I used a new product called TriCon wiring from Brintec Corp.

TriCon wiring contains the power, cable-TV, and telephone lines all in one three-part cable. In cross section, it resembles a Y, with the thick power cable being the tail and the TV and phone lines making up the arms, all joined at the center. With TriCon, every run to an outlet must be a direct home run back to the load center (because of the TV and phone lines), but the wiring's advantages are twofold. First, you save labor by pulling only one cable instead of three. Second, you have the convenience of phone and TV jacks, as well as a power outlet, at any TriCon recepta-

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The roof was raised and the living-room ceiling eliminated in this ranch; sky windows admit the sun to change the atmosphere—and character—of the house. Roof framing was stained with Benjamin Moore Tahoe Brown; staircase was originally a closed-in stair leading to a 6½-ft.-high unfinished attic.



Bird's-eye cutaway (far right) shows the addition's floor plan. Inset shows what was added to the existing ranch. Top and above: Wood stove is the centerpiece for the new den, while the half-wall bookcase adds to the warm atmosphere. Tops of the bookcase and shelves were laminated with Formica Colorcore; the rest was enameled. Master bedroom (above right) and den sport Colony Plank oak flooring. A 16-ft. closet is behind the bed; office and bath are to the right, out of view.



cle. Want to relocate the TV or telephone? Just move it and hook up to any available outlet.

Not everything went smoothly with the wiring, though. When the local New York state fire underwriters' inspector came to check the electrical work, he wouldn't pass it because neither he nor his superiors in Albany had ever seen or heard of TriCon—even though it was Underwriters' Laboratories-approved. And I couldn't close up my walls until he gave his approval. Before the whole affair was straightened out, I had lost at least two months' working time at a critical stage in the project.

Tricks of the trade

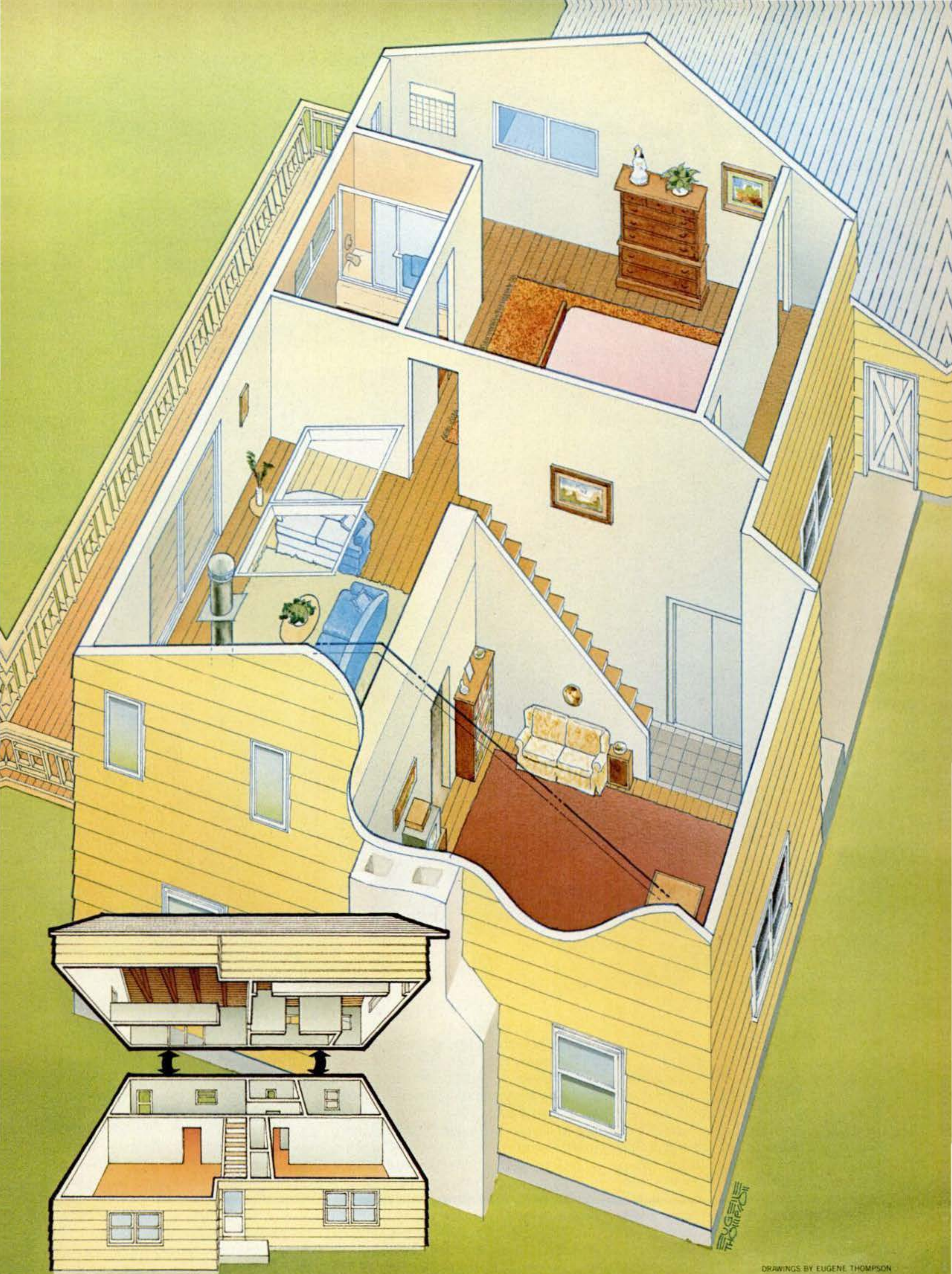
Getting back on track, I installed the rigid insulation, then the drywall,

using two-inch cement-coated nails to get at least an inch of penetration into the studs. But because I had built a wraparound wood ceiling (see photos), how would I finish off the top of the wallboard?

I borrowed a trick from my father, a retired commercial carpenter contractor. At the top of the walls, 10 inches down from the ceiling, the rigid insulation is flush with the wood, so I ran the wallboard 1½ inches above the wood-panel joint and capped it with metal J-mold. The result is an arrow-straight architectural shadow line that's easy to paint: There's no need to cut with a paintbrush at the top because the drywall is on a plane ½ inch out from the wood surface.

Another trick concerned the window

[Continued on page 88]



Adding a sunspace—

PHOTO BY BEN DAY



By JACK HORST

Conservatories, sun rooms, greenhouses, solaria: They're all names for the glass-walled rooms, usually aluminum-framed but sometimes made of laminated wood, that have become increasingly popular among homeowners. These structures—with their prefabricated parts, integral insulation, and appealing styling—are economical, attractive additions to any house, new or old.

As an engineer, I'm interested in

sunspace technology, so I jumped at a chance to watch Tom Nova of Energy Shield Systems erect a sun room. Nova and two other experienced workers were installing it on a house under construction in Dover, Vt., but they'd use the same materials and techniques to put up additions to existing houses.

The glass room that Nova built is a bit larger than the one pictured above; both are made by Sunplace, Inc., of Hinesburg, Vt. Four 38-inch-wide bays look out on the yard, and the end walls are two bays deep (or six feet nine

inches). The unit cost about \$6,000 installed. Work was completed in a day and a half, except for a few finishing details. You can use the same procedure to erect a similar unit.

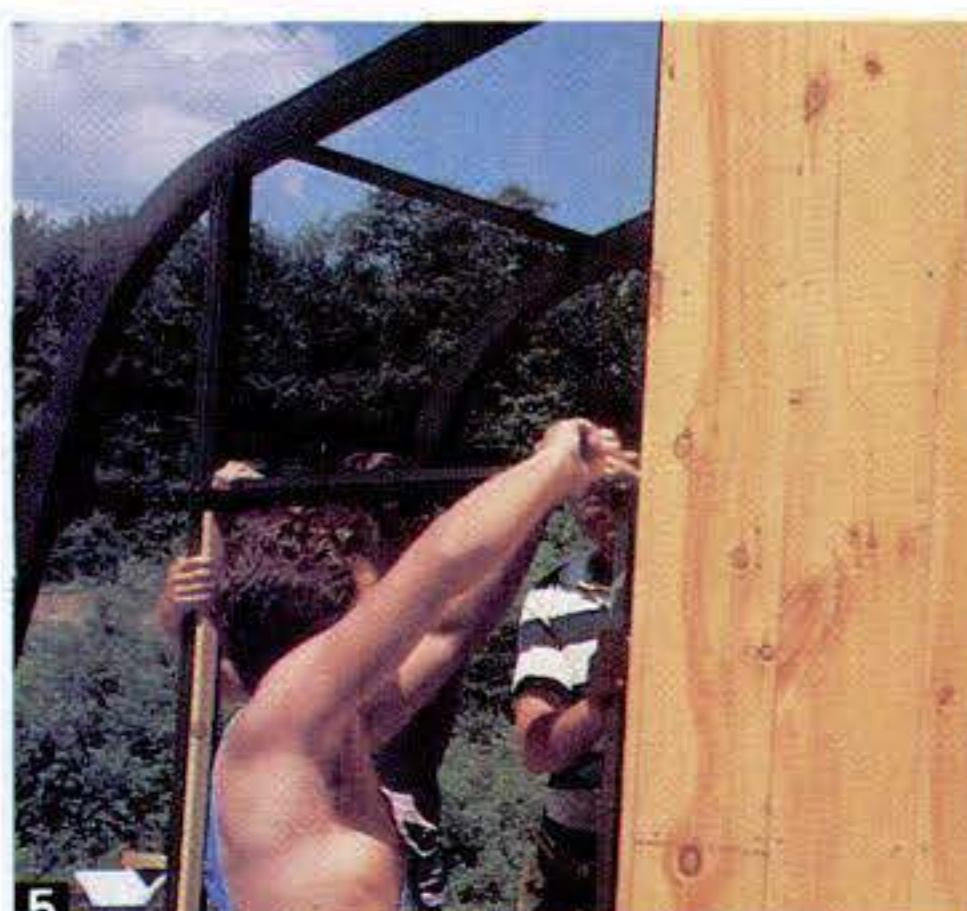
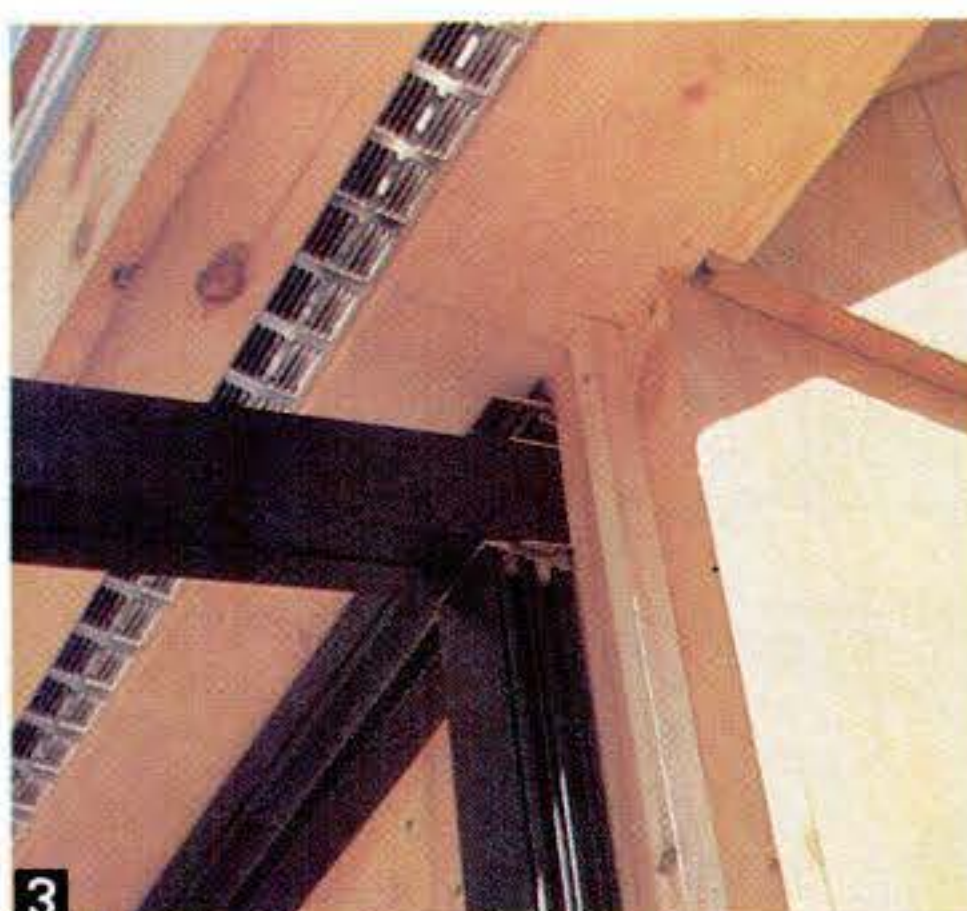
First, you'll need a foundation. The Dover house has a concrete slab 14 feet long and seven feet wide, set nine inches lower than the living-room floor. Since no interior wall divides the living room and the step-down sun room, Nova constructed a "splice" by lag-screwing 2×4s to the house exte-

Continued

FAST

A professional engineer checks out the installation of a typical aluminum-framed, prefabricated “glass room”—today’s hottest home-improvement add-on. His insights can help you decide whether such a project is practical for your home.

INSTALLATION PHOTOS BY THE AUTHOR



1 When you're sure the subsills and attaching surfaces on the house are flat and the corners are square, caulk the back sides of the ridge, end-wall bars, and sills. Lag-screw them into place.

2 Line up the screw track running along the glazing bar's center line with pre-drilled holes in the sill and ridge.

3 End-wall bars have aluminum plugs, called spigots, that attach to glazing bars. Glazing bars slip into a slot in the ridge. Later, glass slips into a similar slot above the glazing bars.

4 Screws fit through pre-drilled holes in muntins (horizontal beams) and the screw track in glazing and end-wall

bars. A wood template ensures proper spacing. Muntins extend over a maximum of three bays.

5 Install the top muntin for a 40-in. sliding window. Cut 1-by-2-in. spacer templates according to the manufacturer's instructions.

6 Place multi-finned vinyl gaskets in slots in glazing bars to keep out moisture. Weep channels on either side of the screw track carry leakage or condensation into drain holes in the sill.

7 Apply 1/16-in. double-stick tape to the sill. Just before installing the glass, remove the blue backing. Place the glass panels on the tape to form a seal.



rior. The greenhouse rests on 2×6 subsills lag-screwed to the slab.

Tack the roof ridge, end-wall framing bars, and sills into place temporarily on the 2×4 and 2×6 mating surfaces, and readjust them until the dimensions of the greenhouse match the manufacturer's specifications. When all the corners are square, caulk the back sides of the metal beams and lag-screw them down permanently (see photos).

The glazing bars, which are the primary structural parts, go up next. They're hollow two-by-three-inch rectangular aluminum extrusions. Like the other metal parts, the glazing bars are pre-cut, pre-painted with a baked-on enamel, and pre-drilled at the factory. To assemble them, line up the

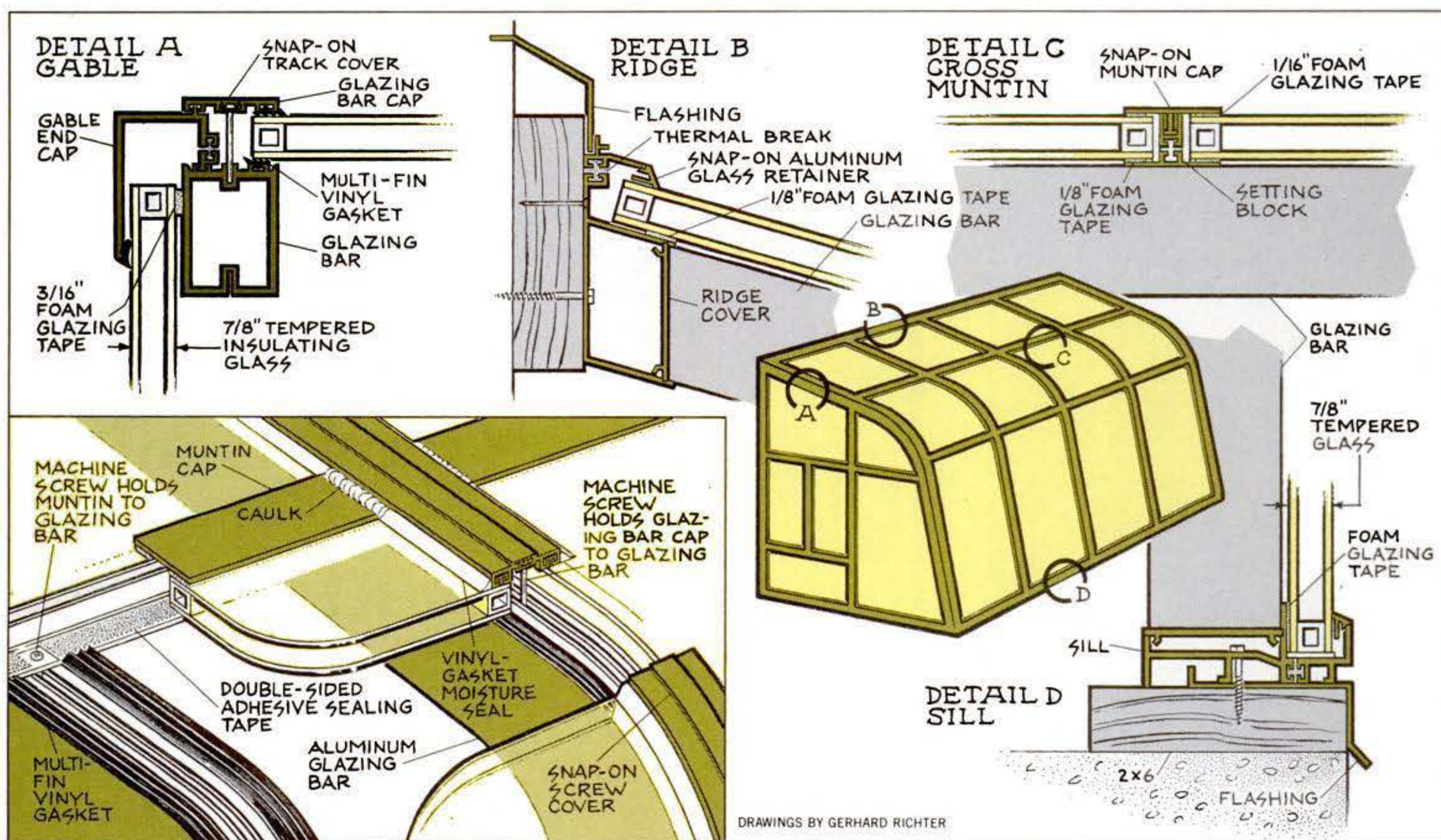
screw track running along each bar's center line with holes in the sill and ridge. Fit aluminum plugs into the hollow tops of the end-wall bars, and attach them to the bottoms of the glazing bars.

The muntins (horizontal beams) are the only remaining structural components. Cut wood spacers to the lengths specified in the installation manual, and use them to position the muntins across the glazing bars. If your sun room has windows or doors, attach the frames with screws.

Like most prefabs, the Sunplace glass room uses a "dry glazing" system. The glazing panels are two sheets of tempered 1/8-inch clear glass with a 5/8-inch hermetically sealed air space between them to improve thermal

efficiency. Tempering makes the glass so tough that it's safe to walk on the roof panels once they're installed. You can also order the panels with a bronze tint that filters out about 15 percent of the light and heat, or with a Solar Cool coating that reflects about half of the heat transmitted through clear double-paned glass.

You weatherproof the sun room with special gaskets and double-stick tape that press against the glass and keep out moisture. Check the fit of the panels before you remove the blue backing on the sealing tape. It's almost impossible to move the glass once this tape has taken hold. When the glass is in place, secure the glazing-bar caps and snap on the muntin caps. Your new glass room is ready to use. **PS**



Is a sun room right for your house?

Doug Taff, president of Sunplace, Inc., says the majority of the residential glass rooms his company sells are add-ons to existing houses. But a glass room won't satisfy every homeowner's space needs, location, and budget. I asked Taff how an owner should decide if a prefabricated greenhouse is right for his house. Here's his list of the five factors you should consider:

Purpose: How do you plan to use your sunspace? Glass rooms are best suited for "outdoor-type" uses—to house a whirlpool spa or potted plants, for example. They can also be used to add living space to a kitchen or dining room, or to create a sunny family room. But think twice about using a sunspace as your guest bedroom.

Location: Where will you build the sunspace? In the northern states, the ideal location is a sunny spot where you'll get the most heat. In southern regions, you'll want a shady site. The location should also afford some privacy. And you should avoid potential hazards like falling tree branches or icicles.

Aesthetics: A glass room can add to the attractiveness and value of your house, but only if you choose an appropriate unit. Prefabricated sunspaces come in many styles and almost any size. Select one that will blend with your house's architecture and environment.

Cost: The average glass room costs about the same amount as a conventional room addition. You can reduce your expenses by using

an existing concrete patio or carport slab as a foundation. Accessories such as ventilating fans, thermal shades, or low-emissivity glass, which allows heat in during the day but retards its escape at night, will increase cost. But you can justify purchasing these extras if they significantly reduce heating bills or increase the overall value of your house.

Dealer reputation: Nationally known sunspace manufacturers choose their dealers carefully and usually stand behind their products. Even so, it is wise to check with several former customers before selecting a dealer. Pick one who guarantees his work, or—if you plan to install the add-on yourself—make sure the dealer agrees to provide plenty of advice and instruction.—J. H.



PHOTO BY THE AUTHOR

Legendary performer

A turbine-smooth V6 engine and unique anti-lock brakes help the Legend Coupe go head to head with BMW and Mercedes-Benz.

By TOM WILKINSON

Audacity. It's not a word usually associated with the Japanese. But when Honda Motor Co. introduced the Acura Legend last year, one had to wonder. Launching an entirely new car line and naming its flagship sedan the Legend could hardly be called modest.

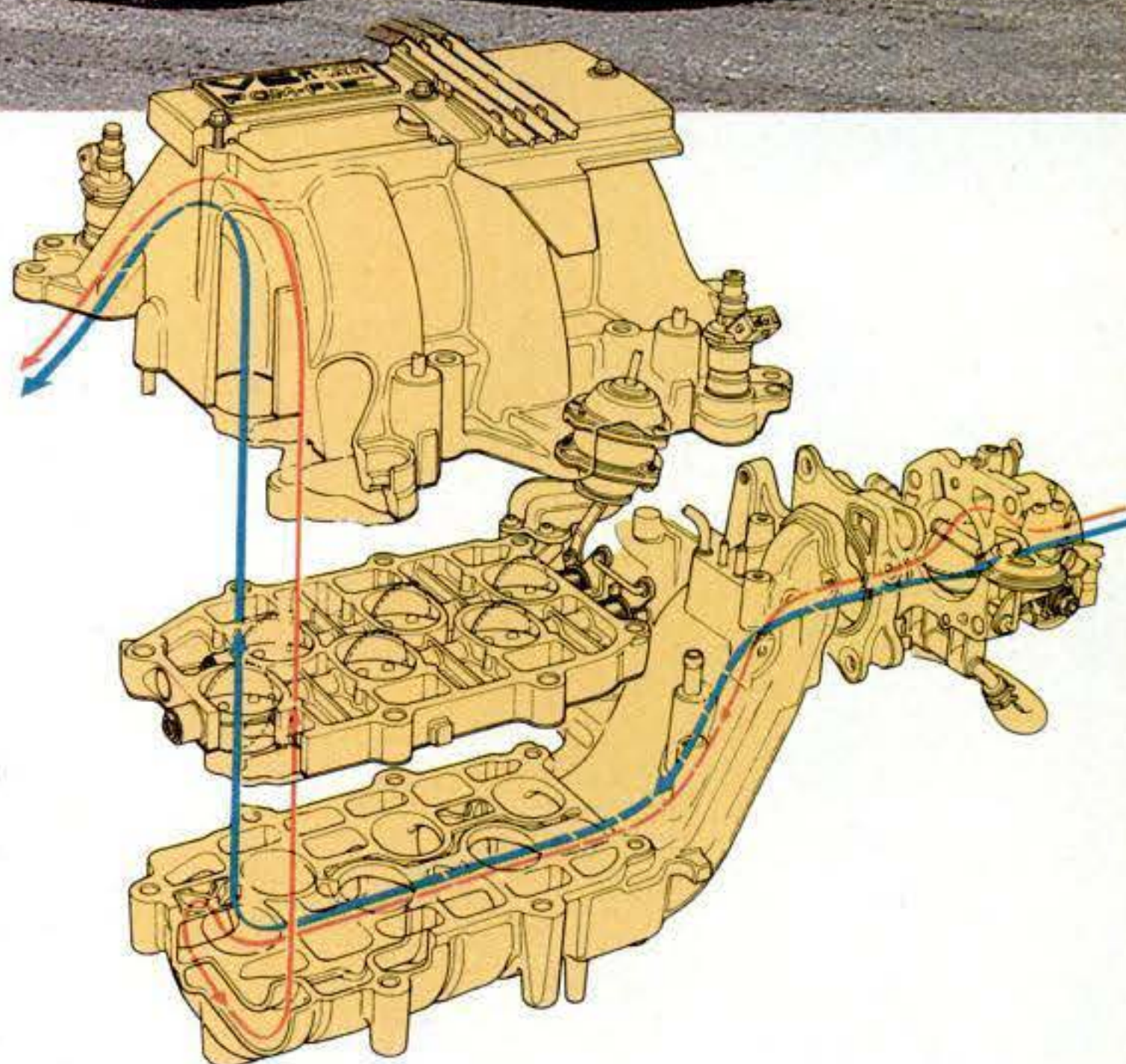
Now comes another audacious move, the Legend Coupe. With its four-valve V6, leather upholstery, and anti-lock brakes, it is designed, says Honda, "to compete with the finest European automobiles, in every category from performance and elegance to value and reliability."

Strong words. But based on three days of driving a variety of Legend Coupes, I think Honda just may succeed.

The body shell for the Coupe shares only a few floorpan stampings with the sedan. Honda engineers said special attention was paid to making the body feel rigid, and I detected no rattling or flexing on the roughest roads. Large windows make the Coupe feel light and airy, and an adult-sized back seat was a pleasant surprise.

For the Coupe, rear suspension has been changed from MacPherson struts to upper and lower control arms for better camber control. Springs and shocks are also stiffer. I found the ride firm but not harsh, and handling was remarkably nimble for a 3,000-pound car.

The 2.5-liter V6 engine from the sedan has been overbored to 2.7 liters. A variable intake system has been added, which keeps intake air velocity high at low engine



Acura's variable intake system broadens the engine's torque curve by routing air through long, narrow passages at low engine speeds, then opening wider passages at higher rpms.

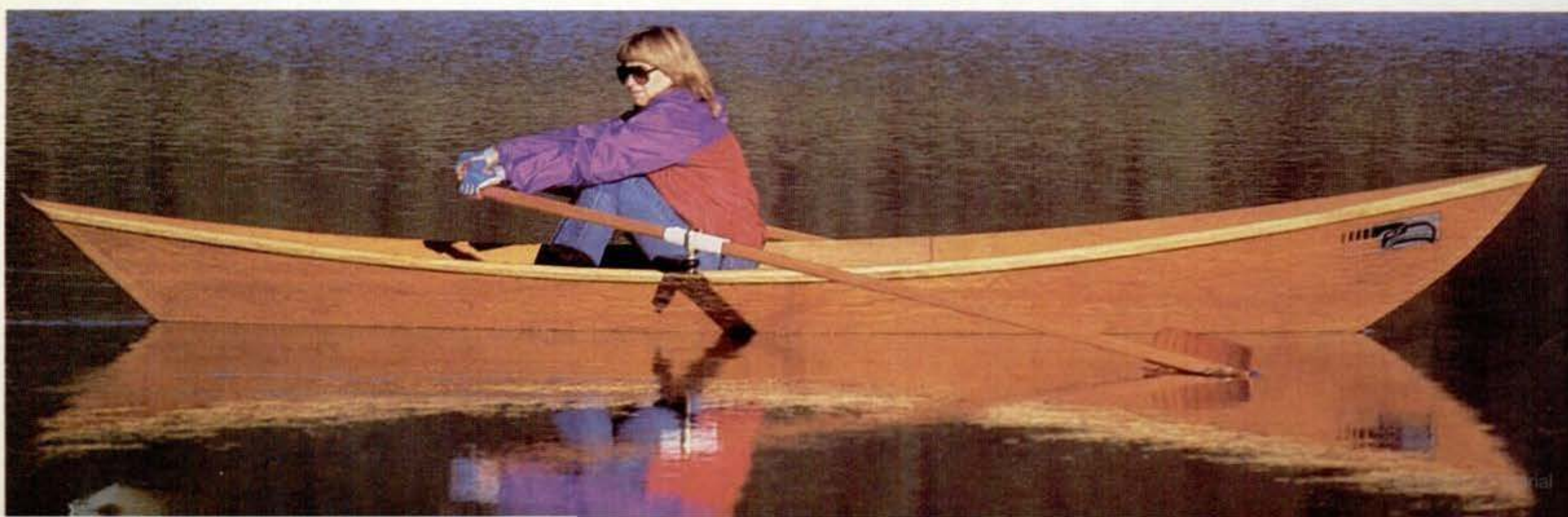
speeds and tunes the pressure pulses generated by the opening and closing intake valves so that the pulses push more air into the cylinders. As a result, the torque curve for the Coupe engine is nearly flat over the entire driving range, unlike that of the sedan, which has a sharp peak at 4,500 rpm. The engine was so smooth that I often found myself cruising in third gear rather than fifth, and I more than once triggered the fuel cutoff at 6,600 rpm without having any clue that the engine was spinning that fast.

The L and LS versions of the Coupe come with leather upholstery standard, and are equipped with Honda's own anti-lock braking system, which the company calls ALB. Honda claims design details make ALB superior to the latest Bosch and Teves systems, though in operation it feels much the same. Also standard on the top-of-the-line LS is a driver-side air bag. Prices will range from \$20,000 to \$25,000, depending on options.

The Acura name doesn't yet have the panache of the German marques, but if Honda keeps building cars like this, it's only a matter of time. Maybe the choice of that name wasn't audacity after all. Maybe it was just confidence.

PS

SLIDING-SEAT



DORY

A cross between a fast rowing shell and a weekend family boat, this nimble craft is built from thin plywood bonded and sealed with epoxy. No metal fasteners are used.

By **PAUL and MARYA BUTLER**

Photos by Paul Butler

There is a thrill in moving fast through the water under your own power, the bow of the single-seat boat slicing the surface with a hissing sound on a quiet early morning when you're the only person on the lake. There's only one hitch: You can't share the pleasure with a passenger.

We've designed a simple-to-build multipurpose dory that combines some of the features of a fast rowing shell with the qualities of a family weekend boat. Although not as stable as a wider and heavier boat, it is more comfortable and safer than a sensitive rowing shell. And though designed primarily as a one-person boat, it can carry passengers fore and aft—as long as they sit on the bottom of the craft to maintain a low center of gravity.

With its light weight and smallish size, the boat is not intended as the supreme rough-water craft, but it will nevertheless handle wind chop and moderate waves that would swamp a rowing shell. And it is still small enough to be car-topped to the bay or lake for an early morning row. Because the dory is built from thin hardwood plywood that is bonded and sealed with epoxy, it is light and strong and will resist the traditional boat problems of rot, delamination, and water soak [*"Wood-Epoxy Construction," PS, March '84*]. In fact, a builder who is concerned with keeping weight to a minimum can build a hull for this dory that will tip the scales at less than 60 pounds—even with the two large fore and aft flotation compartments.

Light weight means the boat is faster through the water, and it's easy to load and unload from atop a vehicle. Because the sliding-seat mechanism is easily removable as a unit, it can be hauled separately and refitted when the boat is unloaded.

Although the dory can be fitted with traditional thwart seats, most builders are likely to choose a commercial sliding-seat mechanism. Such a seat takes a bit of practice to get used to, but it provides by far the best rowing performance, as well as a good upper- and lower-body workout for the rower.

The complete sliding-seat mechanism and its associated hardware are available from Martin Marine Co. (Box 251, Kittery Point, Maine 03905). To make the setup work best, you also need a balanced pair of nine-foot, six-inch spruce spoon oars (Martin Marine stocks these, too). When the dory is used for fishing in rough water or for carrying gear and passengers, the sliding seat is best replaced by a detachable wood thwart; a pair of eight-foot spruce oars will make the dory much more manageable in these situations. The shorter oars are also the best choice for beginners and children.

The boat contains two sealed flotation compartments, which are made watertight with epoxy fillets (see drawing); once bonded to the hull, they become primary structural members. Even when the boat is full of water, the wood hull and flotation compartments will support one

Continued

A natural finish shows off the attractive grain of the dory's hardwood plywood hull (top and far left). The sliding-seat mechanism (left) helps you sprint across lakes—double the fun of an indoor rowing machine.



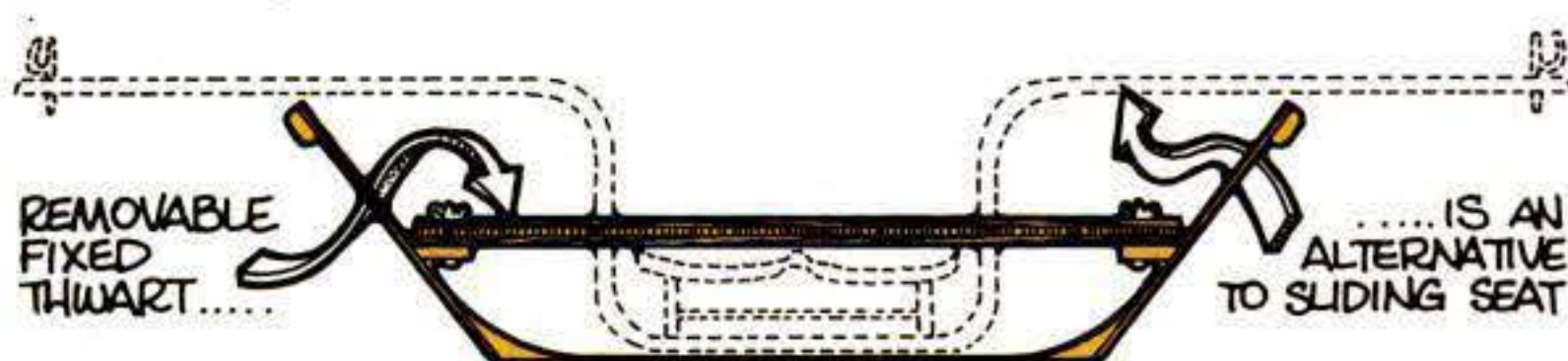
person with shoulders out of the water. The compartments may also be fitted with screw-in access hatches that convert them to dry storage compartments.

Using the wood-epoxy building method eliminates much time-consuming fitting from the construction process. The boat is built without metal fasteners of any kind; the plywood pieces are joined with a simple butt joint reinforced by an interior butt block. The chine—where the sides and bottom meet—is filleted on the inside and wrapped on the outside with fiberglass tape saturated with epoxy resin.

The dory's bottom is coated with black graphite powder added to the resin to produce a hard low-friction surface.

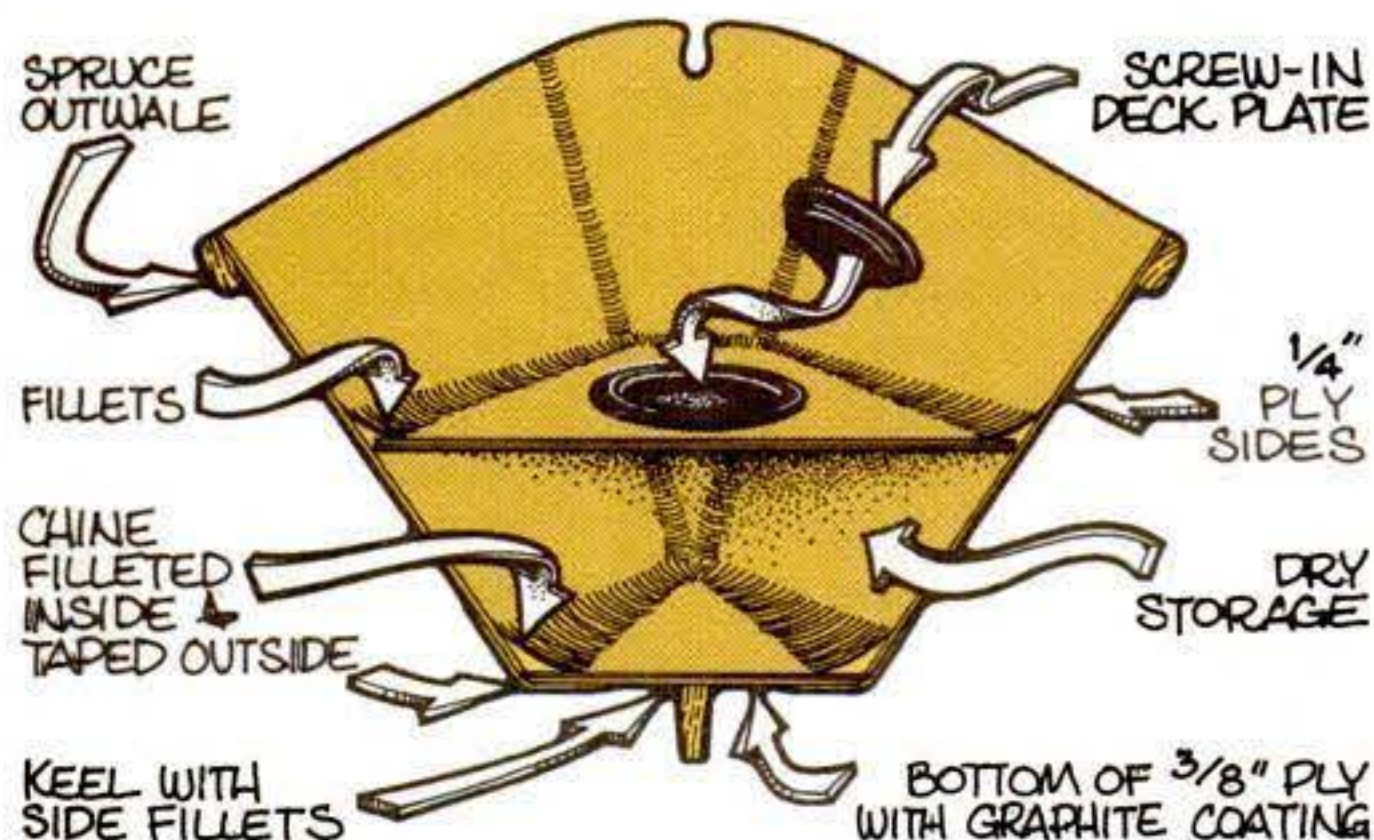
The wood-epoxy dory—we christened ours *The Osprey*—is built upside down using a simple temporary-frame system. It does not require exacting lofting or previous boat-building experience, and is entirely within the capability of most home woodworkers. Detailed building plans, including an instruction manual and sources for all materials, are available for \$25 from Butlers (Box 1513, Hamilton, Mont. 59840-1513). **PS**

Wood-epoxy dory construction

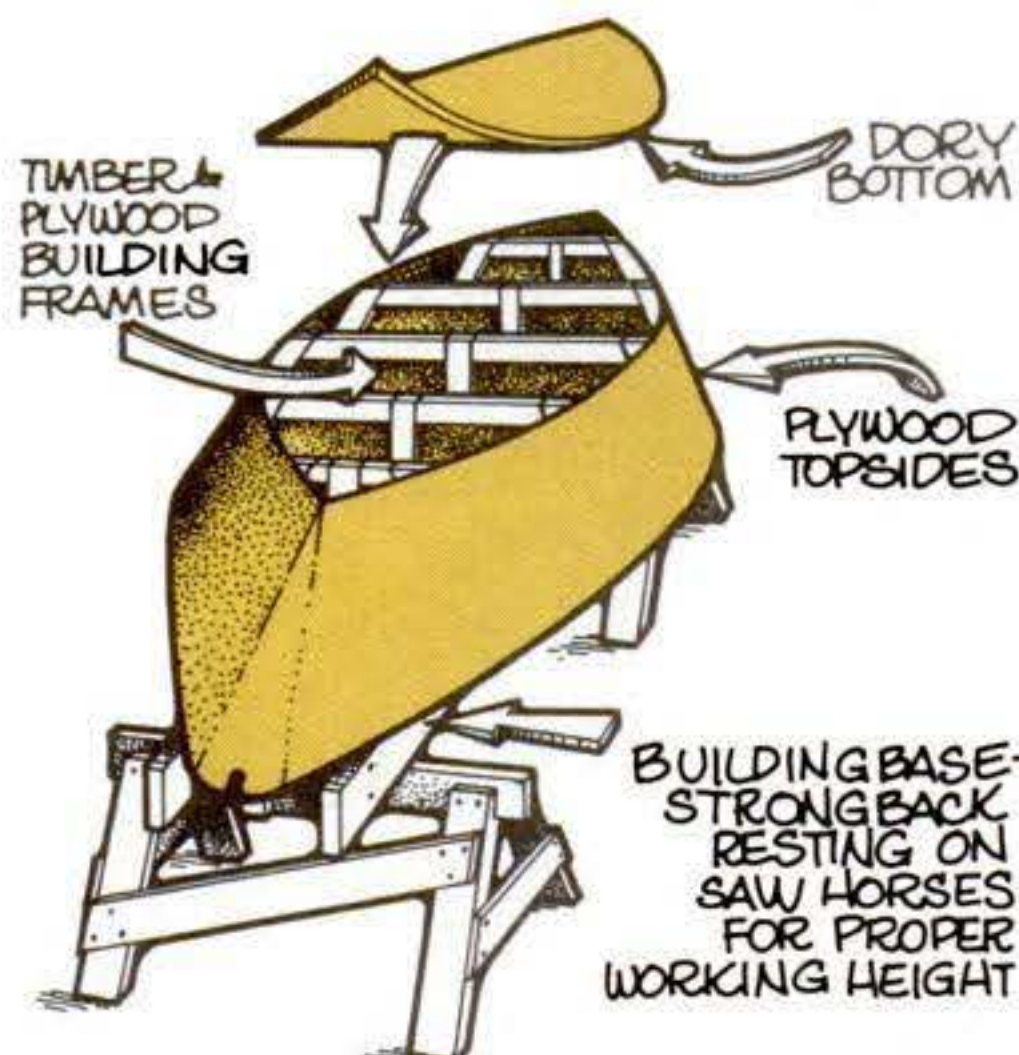


SECTION THROUGH DORY AT SEATING STATION

SECTION THROUGH AFT COMPARTMENT IN DORY



The detail at top left shows construction of the optional plywood thwart that replaces the sliding seat. The sides of the dory (above) are made of quality 1/4-in. hardwood plywood that is butt-joined to the 3/8-in. plywood bottom. (Flounder Bay Lumber, Third and O Sts., Anacortes, Wash. 98221, will ship anywhere.) Epoxy fillets reinforce and seal the inside of the joint, while the outside is wrapped with epoxy-soaked fiberglass tape. Temporary assembly frames (top right) made from scraps of plywood and lumber hold the hull pieces in place until the epoxy cures. Before assembly, all parts are finished with three rolled-on coats of West System epoxy (available from Gougeon Brothers, Inc., Box X908, Bay City, Mich. 48707), followed by a coat of clear linear polyurethane paint. If you choose to use domestic AA-grade marine fir ply, you must sheathe the hull with 4-oz. fiberglass cloth to prevent hairline cracks. This will result in a heavier but more abrasion-resistant hull. Filleting detail is shown at center right. The diagrams at right suggest plywood cutting patterns.



THE FILLET PADDLE

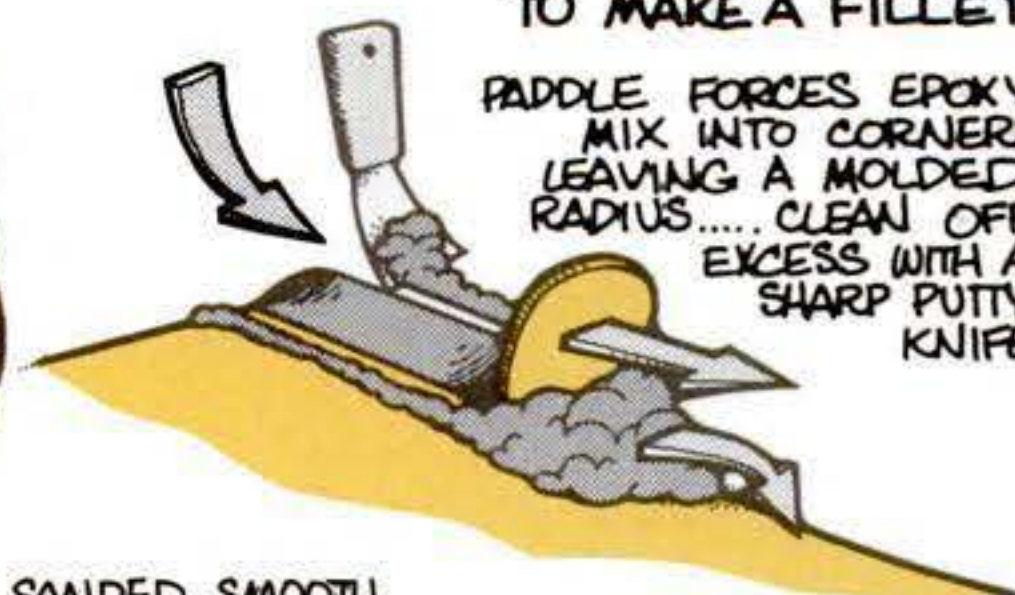
DESIGN 1/8" PLY PADDLE WITH TWO MOST OFTEN USED RADII.....



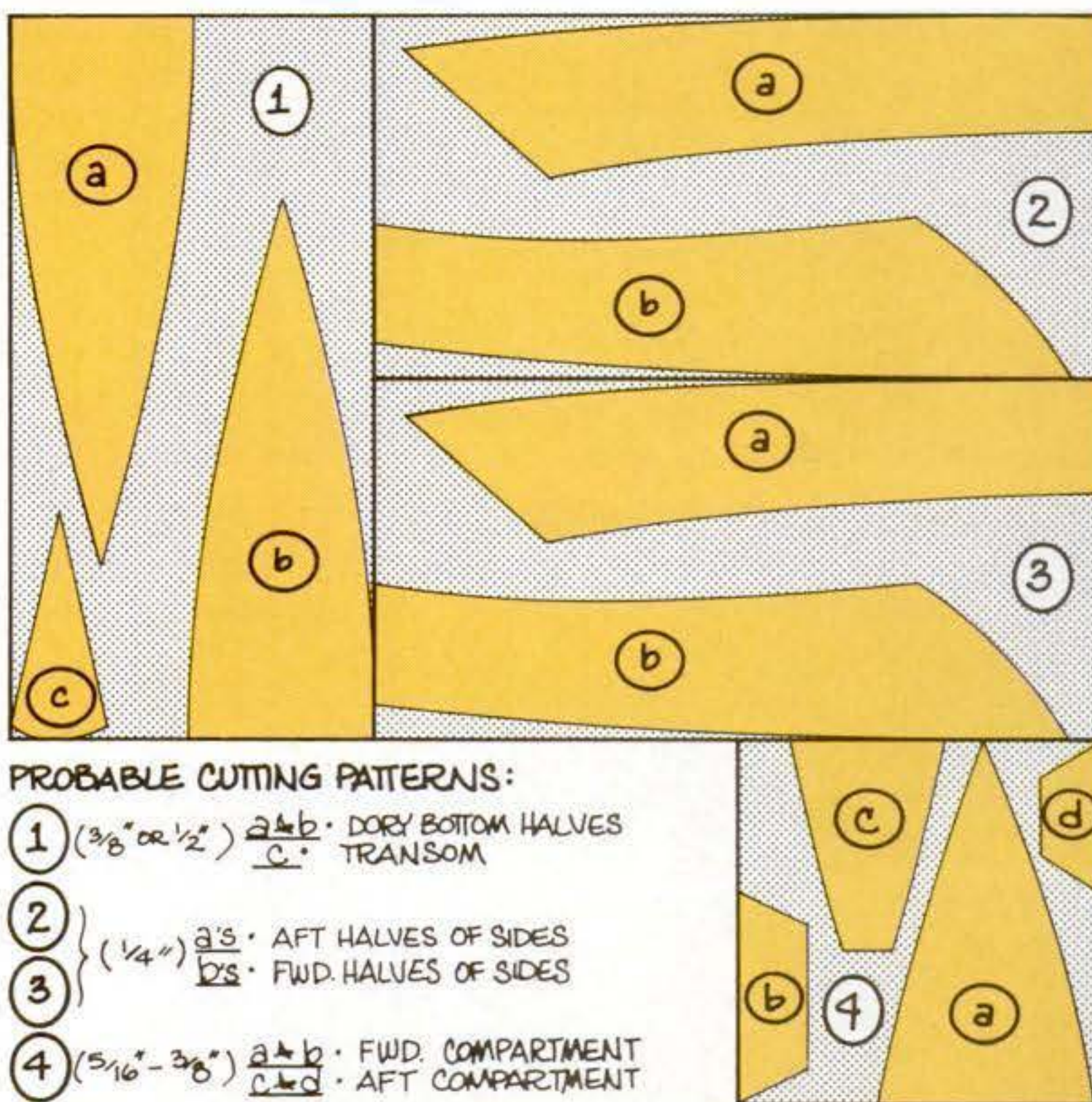
ALL EDGES SHOULD BE SANDED SMOOTH

TO MAKE A FILLET

PADDLE FORCES EPOXY MIX INTO CORNERS, LEAVING A MOLDED RADIUS..... CLEAN OFF EXCESS WITH A SHARP PUTTY KNIFE



DRAWINGS BY MARYA BUTLER



TECHNO-TRACTORS

So you think a tractor is a tractor is a tractor? Not anymore. Two new tractors from Japan show that even these once-simple garden machines can't escape the long arm of technology.

By JIM SCHEFTER

The rain pelted down as Craig Crippen and I mounted our twin Honda RT5000 utility tractors. We were aimed for a muddy field at the company's headquarters in Torrance, Calif., to test this new—and unusual—tractor that offers four-wheel drive and four-wheel steering. These weren't ideal conditions for testing any kind of grounds-keeping equipment, but Crippen, an assistant technical manager at Honda, shouted "Follow me!" and sped away at the machine's top 7-mph speed.

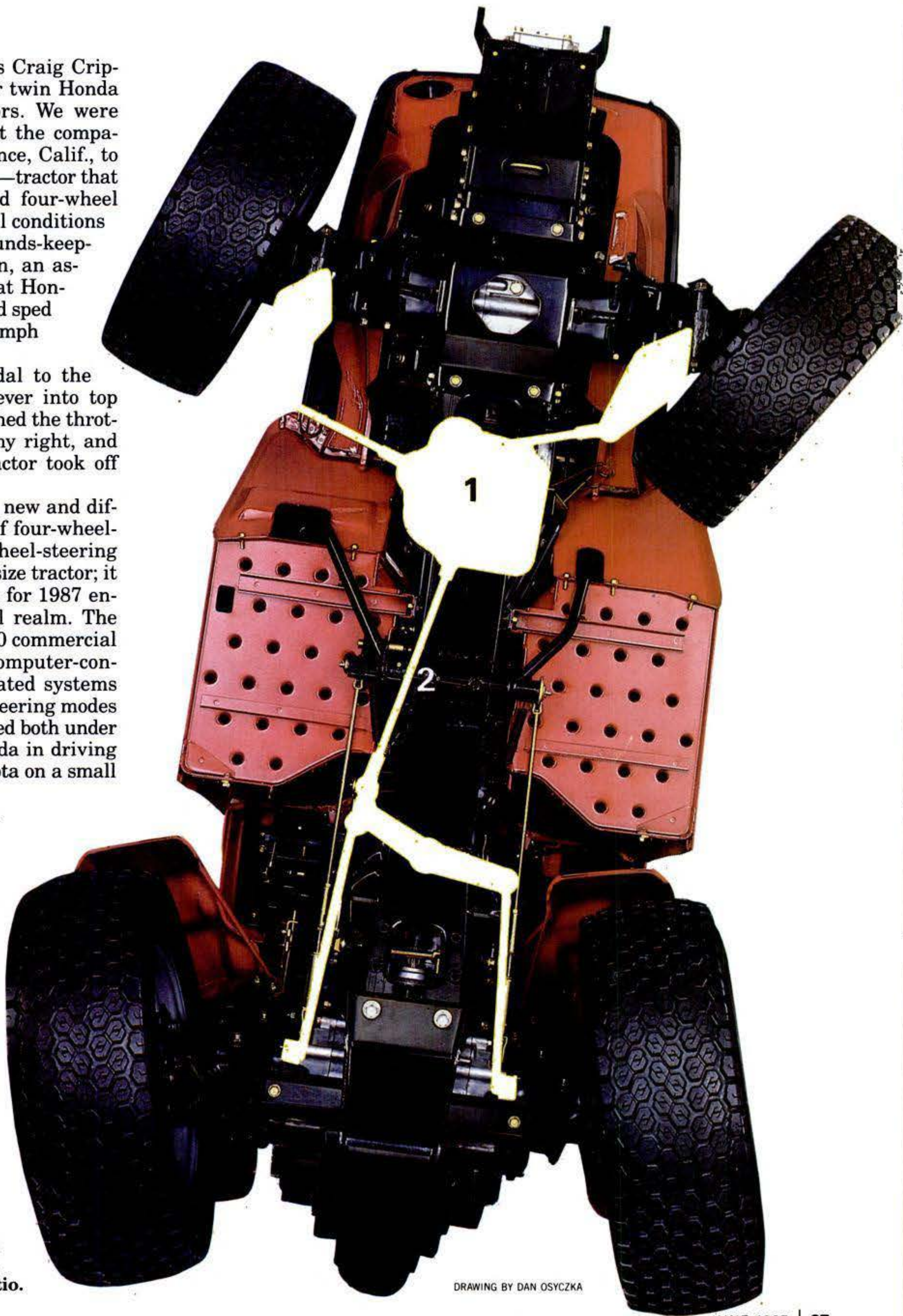
Dropping the clutch pedal to the floor, I toggled the shift lever into top gear with my left hand, pushed the throttle up to maximum with my right, and popped the clutch. The tractor took off smoothly after Crippen.

What makes the RT5000 new and different is the combination of four-wheel-drive (4WD) and four-wheel-steering (4WS) systems in a garden-size tractor; it is one of two small tractors for 1987 entering that new four-wheel realm. The other is the Kubota PX-2100 commercial 4WD tractor, which has computer-controlled, hydraulically actuated systems and allows three different steering modes and full remote control. I tried both under limited conditions: the Honda in driving rain and mud, and the Kubota on a small and soggy corporate lawn.

"Drop the plow and cut a furrow," Crippen yelled from his tractor seat when I stopped in the field. I shoved the up-down lever to "down," and the plow sank into the muddy soil.

[Continued on page 111]

Single steering gearbox (1) in Honda system controls both front and rear wheels via two rack-and-pinion sets. Steering input is transferred to the rear by an offset relay pull rod (2). Intricate gearing causes the rear wheels to turn about 2° in the same direction as the front at the start of a turn, then turn in the opposite direction at a 2:1 front-to-rear ratio.



DRAWING BY DAN OSYCZKA

treatment. I used Caradco windows throughout the addition, but I had two problems: Because of the Energy Shield insulation, the finished wall would be ½ inch out from the window frames; and I didn't want to create bulky-looking window trim. Solution: I brought the drywall even with the ends of the frames to create a ½-inch lip, then used corner bead around the perimeter. Spackling and painting the corner bead resulted in a neat-looking opening where only the wood of the window frame is visible.

Before finishing the walls and installing the floors, I had to set up the wood stove—a large catalytic wood-burner from Consolidated Dutchwest. I wanted a wood stove as an auxiliary heat source in the cavernous living area, and because the stove has glass doors, the visible fire provides a cozy atmosphere. (To break up the stratified layers of heated air bound to form in a room with a cathedral ceiling—and to provide cooling currents of air in the summer—I also installed ceiling fans from Beverly Hills Fan

Co.'s new line of five-bladed "designer color" models. These range from high-tech chrome to rich pastel colors. I chose almond.)

In setting up the stove, I followed the guidelines provided by the manufacturer: Whenever you tackle a job like this, carefully read all the recommendations and installation instructions. I constructed noncombustible floor and wall shields using fire-proof underlayment—with a one-inch airspace at the wall—and a new product from American Olean Tile Co. called Terra Pavers. These are a cross between ceramic-mosaic and paving tiles. Because Terra Pavers have a nonporous, easy-to-clean surface, they are ideal for use with a wood-burning stove, where ashes inevitably find their way to the floor.

Ah, the floor—that came next. A wood floor is not difficult to install once you get the hang of it, but it can be time-consuming...especially with random-width planking, which is what I used. Holes have to be drilled for the blind nailing to prevent splitting, and you have to take special care to make sure the wide boards are snugged and nailed properly.

The prefinished, dark-oak Chickasaw Colony Plank floor I installed is made by Memphis Hardwood Flooring; the planking comes in three-, four-, and six-inch widths. The tongue-and-groove design has beveled edges to give it a slightly rustic look; however, the beveling is not uniform, which made it difficult to get all the boards snugged properly. Also, an inordinate number of the six-inch planks were very short, which made staggering the lengths difficult. The prefinished flooring saved finishing time, though, and the final appearance is perfect for a rural home like mine.

Once I had the floor in, doors, trim, and paint were all that were left. I hung solid-pine six-panel doors for the bedroom and bath (bifolds for the closet) and installed 2¼-inch pine colonial casing and 3¼-inch baseboard. Once you get to the paint in a job like this, you know you're home free: After the drywall and trim got an undercoat of primer, a topcoat of Benjamin Moore Navajo White (flat for the walls and enamel for the trim) put the crowning touch on the project. **PS**

LIST OF MANUFACTURERS' ADDRESSES

The following manufacturers were selected for this project. American Olean Tile Co., 1000 Cannon Ave., Lansdale PA 19446; Beverly Hills Fan Co., 12612 Raymer St., North Hollywood CA 91605; Brintec Corp., 1600 W. Main St., Willimantic CT 06226; Consolidated Dutchwest, Box 1019, Plymouth MA 02360; Caradco Corp., Box 920, Rantoul IL 61866; Formica Corp., 155 Rte. 46 CN980, Wayne NJ 07474; Memphis Hardwood Flooring Co., Box 7253, Memphis TN 38107; Benjamin Moore Paint Co., 51 Chestnut Ridge Rd, Montvale NJ 07645; Owens-Corning Fiberglas Corp., Fiberglas Tower, Toledo OH 43659

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Designer bones— computers prescribe the prosthesis

By treating the human skeleton as if it were an inorganic machine, Cornell University engineers have developed a computer-aided system that enables orthopedic surgeons to design ideal replacement bone joints for patients of all sizes and ages. The system, called CAPS (for computer-assisted prosthesis selection), is being evaluated by surgeons at the Hospital for Special Surgery, in New York City.

"Orthopedic surgery amounts to modifications of a machine. The surgeon cuts, shapes, drills, and reams, just as you would with an inanimate machine. The difference is that you can't take the bone out and put it into a jig to work on it," says Donald L. Bartel, a biomechanical engineer at Cornell University's School of Mechanical and Aerospace Engineering, in Ithaca, N.Y. Together with Albert H. Burstein, a biomechanical engineer at the Hospital for Special Surgery, Bartel developed the computer design system that applies mechanical principles to replacing parts in "machines" that have a unique characteristic: Human bones keep on growing and changing after the artificial joint is in place.

"Bone is a living material," Bartel notes. "It responds to changes, including the changes in load from an artificial joint."

The body's long-term response to the new part is one consideration made by the computer program in prescribing an artificial joint. Physicians sitting at a CAPS work station are asked by the computer for the patient's medical condition, age, weight, and bone geometry. Detailed information on the geometry of the patient's existing bones is entered into the computer by tracing X-rays with an electronic pen, although more advanced CAPS systems will take information directly from CT (computerized tomography) scanning machines.

"The surgeon is led, step by step, through an orderly selection process. In the background is a decade of research in developing design rules for the bone systems," says Bartel, adding that the Cornell biomechanics team studied human skeletons of all races at the American Museum of Natural History, in New York City, as well as analyzed used artificial joints for wear and tear.

After CAPS makes its recommen-

dation, it can be overruled or modified by the surgeon. The prescribed replacement joint could be an "off-the-shelf" model from manufacturers of metal and plastic devices, or CAPS may prescribe a custom device. In

the first tests of the CAPS system, biomechanical engineers will compare prescriptions made by surgeons using the computer program with those of experts working without the computer. —Stuart F. Brown

Breakthrough Design Adjustable Socket Kit

U.S. AND FOREIGN
PATENTS PENDING



This One Tool Replaces Twenty Sockets

No more need for a whole set of individual sockets. No more fishing around in your tool kit for the right size. This new CHANNELLOCK 906 Adjustable Socket does it all. Replaces 20 individual sockets. Fits 20 bolt or nut sizes, both metric and standard. Best of all —

- IT'S SIMPLE TO OPERATE. Just turn the knurled collar and the triple action jaws lock into a can't-slip grip on the bolt or nut as shown in illustrations.
- BUILT TO LAST. PRECISION MADE of high grade forged steel. Withstands 1,200 inch lbs. of torque at maximum opening.
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What's New

PRODUCTS/TECHNOLOGY

BY DAWN STOVER

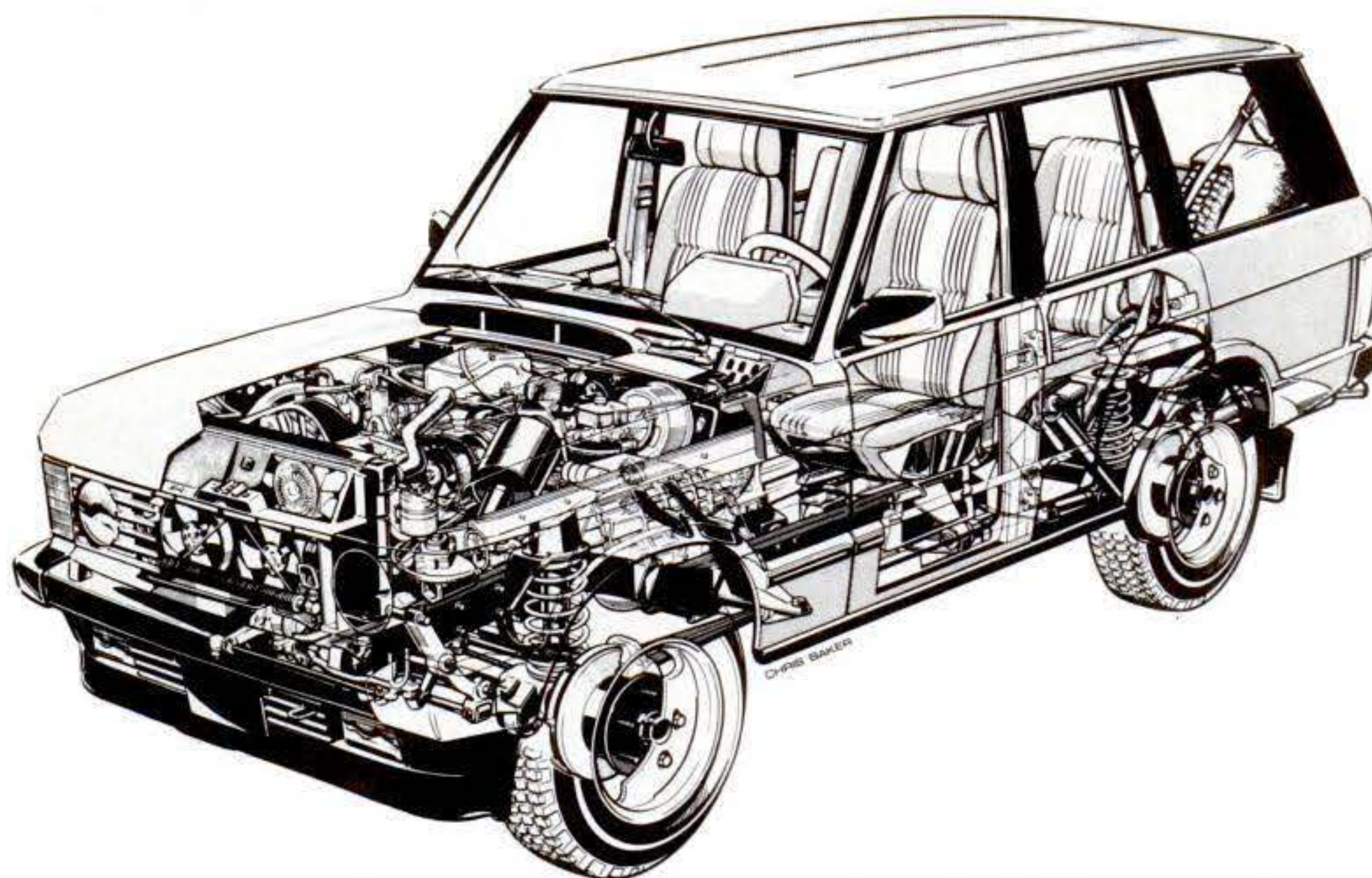


Sports spectacles

Take these pocket-size 5×30 binoculars to the ball park or horse races, and you can watch the competitors while you listen to the announcer on a built-in radio. The \$40 glasses come with a case and earplug. Made by Romor Industries, 15036 Delano St., Van Nuys, Calif. 91411.

◀Luxury off-roader

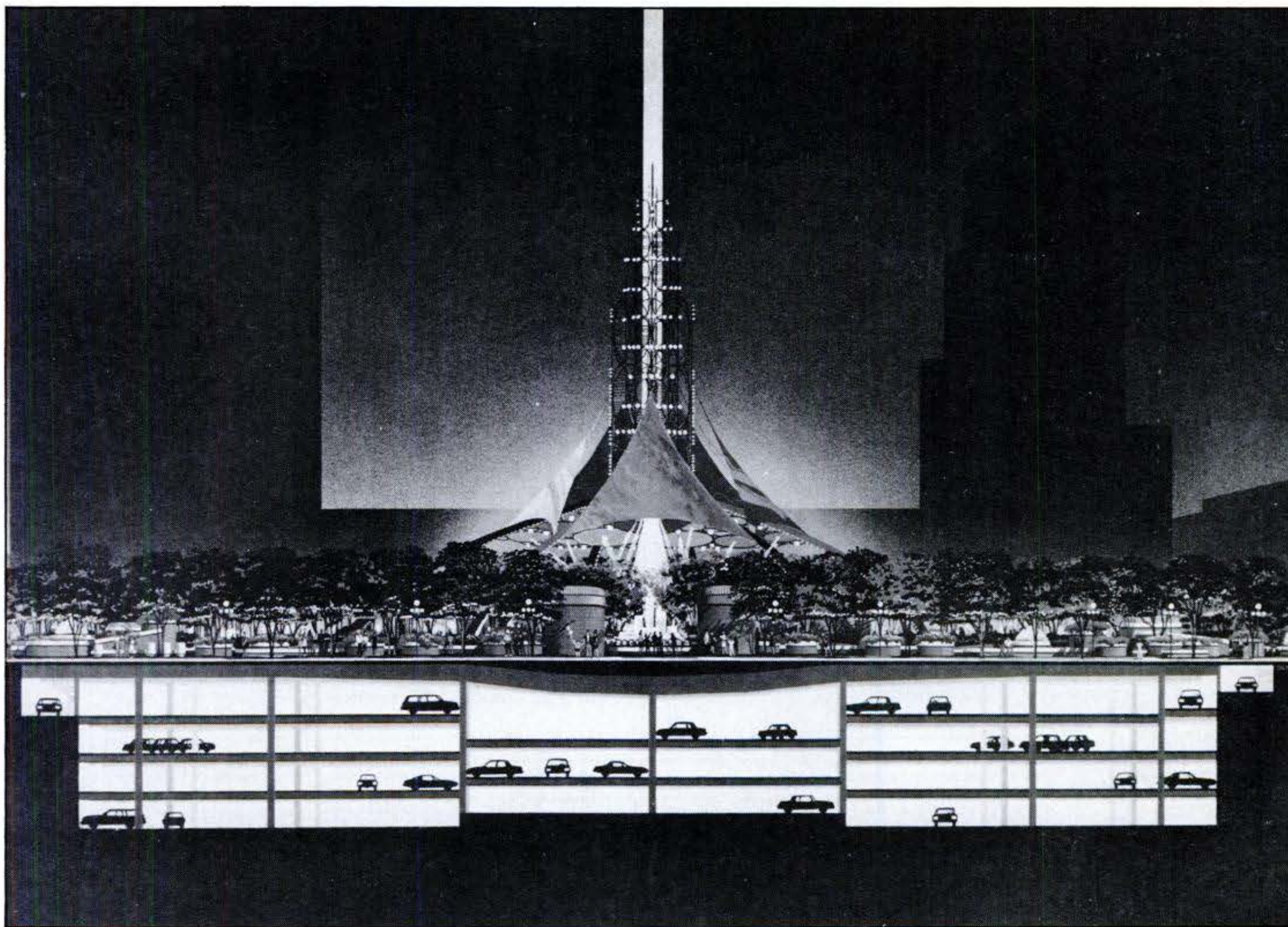
It can climb 45° slopes, ford streams and ponds (as shown below left), or cruise at over 100 mph on the highway, claims Range Rover of North America (Lanham, Md.). The \$31,000 4WD Range Rover has a 150-hp fuel-injection aluminum V8, disc brakes all around, and a Boge ride-leveling unit in the rear. The latter automatically pumps up for carrying heavy loads or for towing, and keeps the vehicle at a constant side height. The Range Rover seats five and can carry more than 70 cu. ft. of cargo when rear seats are folded down—and up to 82 cu. ft. if you remove the rear seats.



Water bomber

The only amphibian in production, the turboprop CL-215T will fight forest fires without having to land at airports to replenish water supplies. Canadair claims it will be six times more efficient than its predecessor, the CL-215. The first flight is scheduled for Sept. '88.





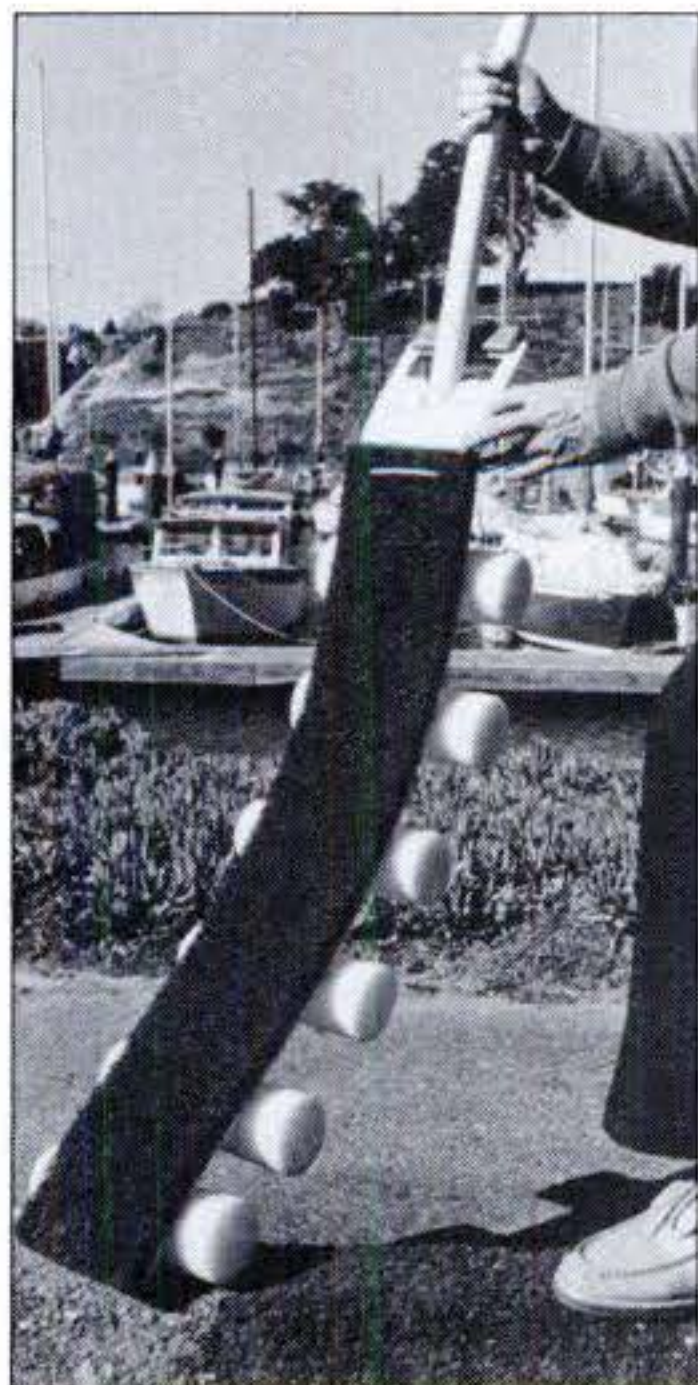
◊ Taiwan's first

The Yue Loong Feeling 101, the first auto launched in Taiwan, is based on the Nissan Stanza's mechanicals, but its exterior skin was done without outside help. Powered by a 1.6- or 1.8-liter engine, the car costs about \$12,000 in Taiwan. If sales go well, it may be exported.



Laser tower

A laser sculpture will be the centerpiece of a park opening in Phoenix, Ariz., later this year. Vertical laser beams will be visible for miles, and scanners will create screen effects on fabric awnings around an amphitheater. Consoles will allow passers-by to manipulate the beams.

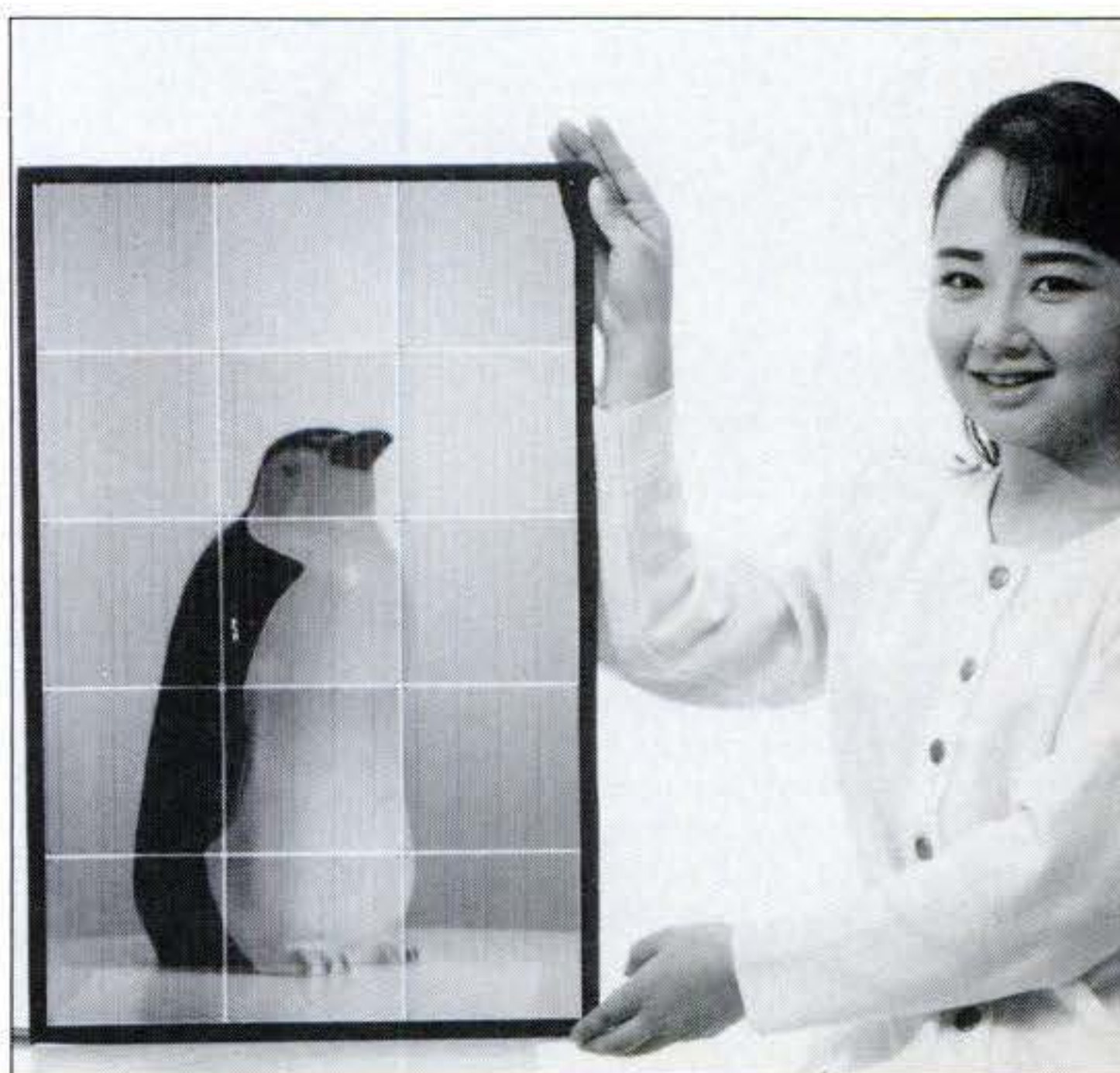


◊ Hull scrubber

Clean your boat without hauling it out of the water or diving. Floats push Dri-Diver against the hull while you rub off marine growth. The \$89 plastic device comes in two styles, for powerboats or sailboats. Dri-Diver, 728 N. Branciforte Ave., Santa Cruz, Calif. 95062.

◊ See-through cell

Solar cells that transmit light while generating electricity may one day be installed in car windows, skylights, and greenhouses. Researchers at Sanyo Electric (Little Ferry, N.J.) say they have made the first translucent solar cell by etching microscopic holes in its silicon film.

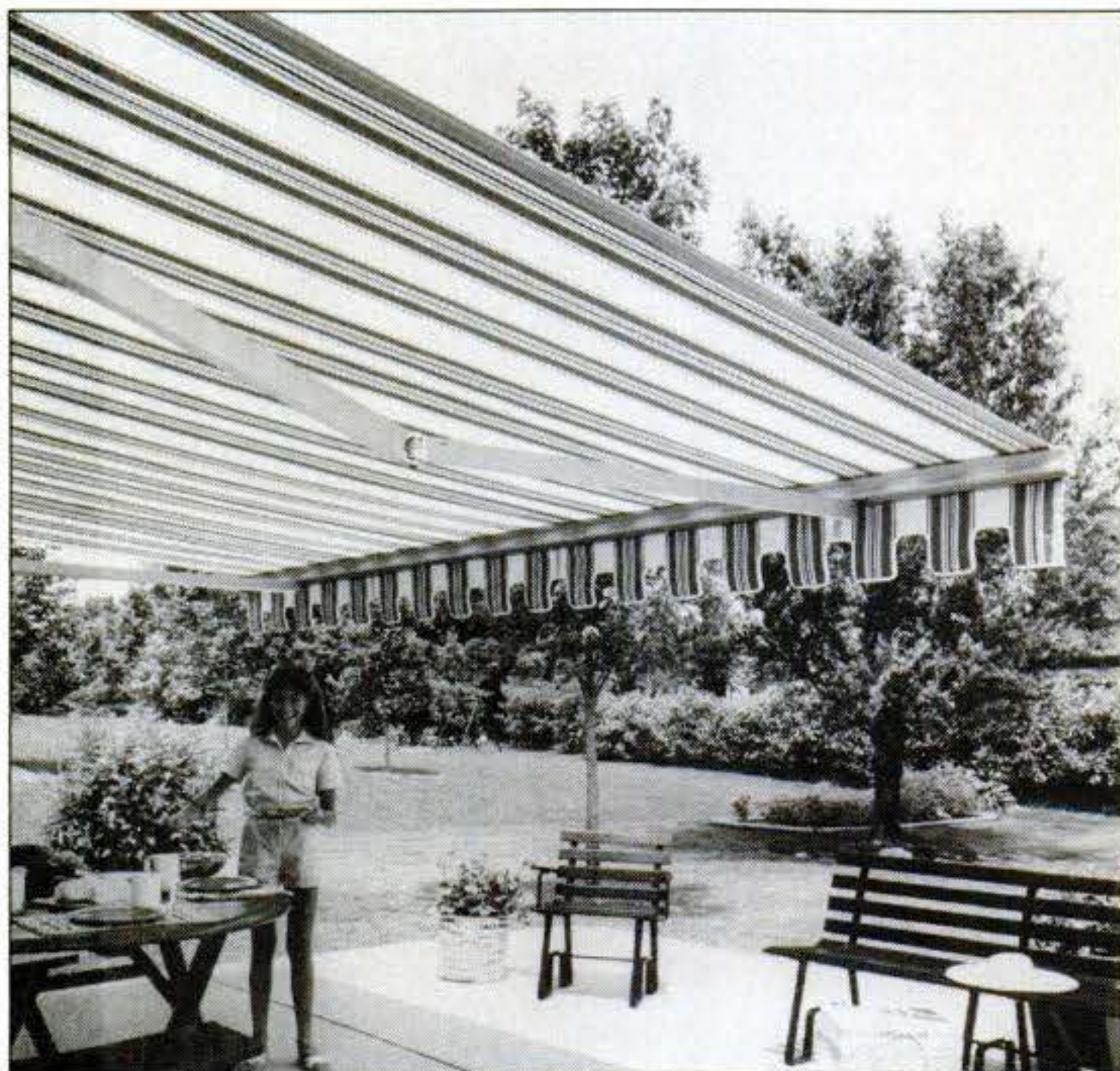


What's New in Home Improvement

BY STEVEN ASHLEY

Hanging lamp jack

Installing ceiling-mounted lamps is quick and easy with Wire Light, a ceiling-fixture jack made by The Wiremold Co. (60 Woodlawn St., West Hartford, Conn. 06110). The \$15 unit consists of a mounting plate and screw-on wiring jack that attaches to a hanging light fixture.

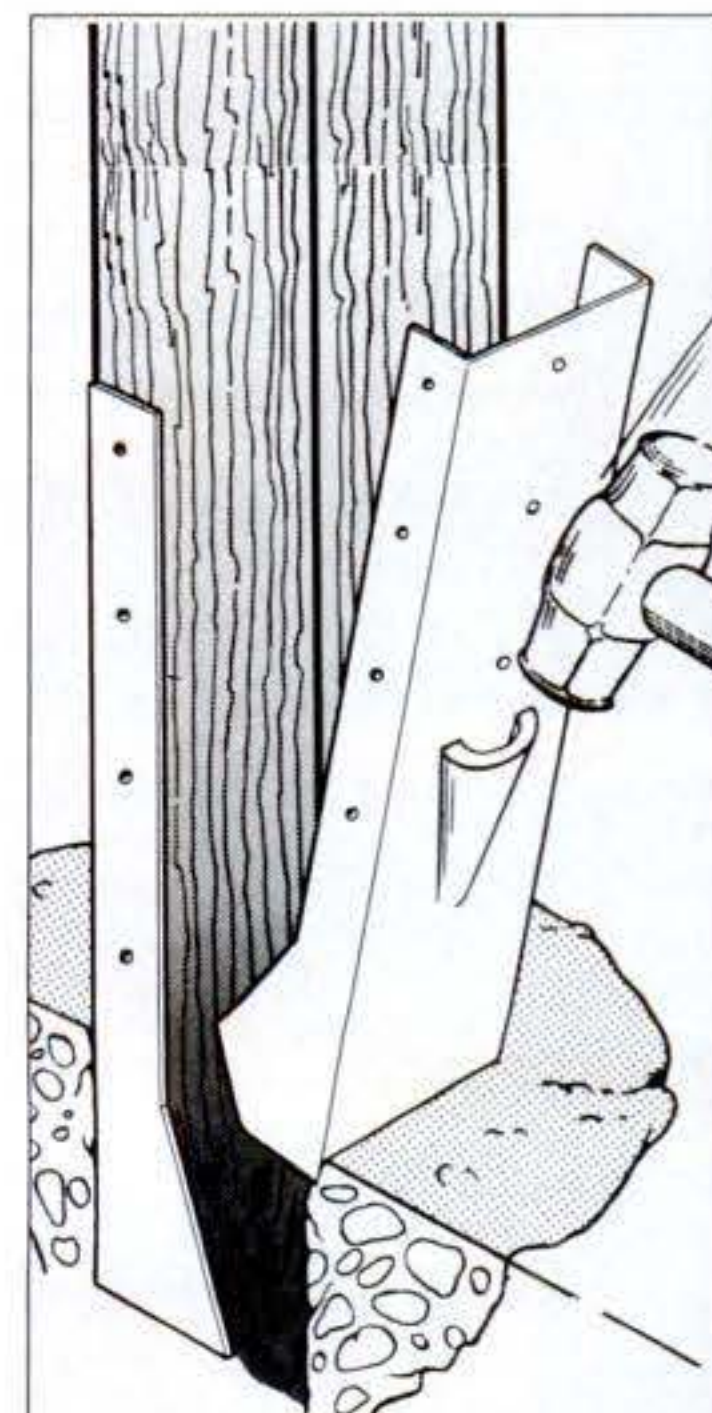


Extendable awnings

Retractable Arm Awnings have hand-crank- or electric-motor-driven extension arms rather than support poles. Sun and wind sensors can control opening and closing. A 10-ft.-wide unit with 8-ft. projection costs about \$1,000. Pease Ind., 7100 Dixie Hwy., Fairfield, Ohio 45014.

Clear caulking

Lexel, an isoprene-and-styrene compound, is tougher and stronger than silicone weatherproofing sealants, claims Sashco Sealants (3900 E. 68th Ave., Commerce City, Colo. 80022). Lexel bonds to virtually any surface and is paintable. A cartridge costs \$7.



Solar air cooler

During the day, the \$829 New Breeze evaporative air conditioner requires no utility power to cool an 8-by-16-ft. room: It runs on a rooftop solar panel. For nighttime, an AC power pack is available. Independent Power Co., Box 649, North San Juan, Calif. 95960.



Rotten-fence fixer

Fencemenders are sheet-metal sleeves that enclose rotted 4x4 wooden fence posts to provide support. The \$13 repair sleeves are driven into a post hole with a sledgehammer and nailed in place. Fencemender Corp., 38592 Cedar Blvd., Newark, Calif. 94560.

Faux tile top

This 1/2-in.-thick cast-limestone-and-resin vanity top looks like real ceramic tile. The tile top's "grout lines" never discolor because the surface is coated with a protective gel. Made by Nautilus (Box 159, Hartford, Wis. 53027), a 19-by-31-in. model with oval bowl is \$133.

A SPA IS A SPA IS A SPA?

A CONSUMER GUIDE

If you've been considering a spa, you're probably already aware of the benefits and pleasures of whirlpool massage. However, not all spas are alike. The true test of any spa is whether it can provide these pleasures conveniently and efficiently. We'd like you to know what to look for when shopping for a spa and show you why the engineers who designed the HOT SPRING SPA® have produced the best spa available today.

1. FULLY WARRANTED MATERIALS AND CONSTRUCTION.

The HOT SPRING SPA is made of the most advanced and durable material of any spa - ROVEL™ (A). Almost all leading manufacturers are turning toward this softly textured non-slip plastic because of its obvious superiority in spa applications. Unlike fiberglass or acrylic surfaces, ROVEL won't peel, blister, crack, or delaminate. As a result, ROVEL is guaranteed to be much more durable than any other spa material. In fact, while most acrylic manufacturers have reduced surface warranties to just one year, HOT SPRING SPA has stood firm with a full five years' coverage. HOT SPRING SPA is the oldest and largest manufacturer of ROVEL spas in the world.

2. CONVENIENCE AND EFFICIENCY.

Most spas have very little thermal insulation, some have none at all! Just how important is insulation? It's the most important feature in private spa ownership! Uninsulated spas will physically not operate in colder climates, making spa use as seasonal as a swimming pool. Further, a marginally insulated spa forces the heater to run continuously, costing you money. Many manufacturers try to compensate for the lack of insulation and their inefficient "air blower" systems by offering gas, 220v., or convertible heaters. While these options are viable in professionally installed, commercial or continuous use applications, they represent an unsafe, inconvenient, and costly alternative for residential use. The HOT SPRING SPA is filled SOLID with 130 lbs. of polyurethane foam insulation (B) and includes a 3½" thick insulating cover as standard equipment (C). This heavy insulation makes it economical to keep the 110v. HOT SPRING SPA heated to your desired temperature 24 hours a day, regardless of location. You can use your HOT SPRING SPA at any time, day or night, in ANY climate, and for just pennies.

3. HYDROTHERAPY JETS.

Vigorous jet action is the key to true hydrotherapy. Only the HOT SPRING SPA gives you the option of powerful fixed jets (22 p.s.i. at each jet) (D), and the unique stroking effects of the MOTO-MASSAGE™. The exclusive MOTO-MASSAGE JET glides gently up and then down the entire length of your back in a continuous sweeping motion (E). In addition, we provide a "warm air" control which can be reached from inside the spa so you can vary the intensity of the jets (F). These features combined with the STA-RITE Max-E-Glas pump provide the best hydrotherapy available today. (G).



4. WATER CHEMISTRY AND FILTRATION.

Look for a large water capacity when shopping for a spa. Units that contain less than 180 gallons make it difficult to maintain proper water chemistry and require frequent draining. In addition, a larger capacity aids in heat retention. The HOT SPRING SPA contains over 325 gallons of water. Unlike many portables that have overlooked the value of good filtration, the HOT SPRING SPA features a huge 45 square foot filter (H). Because of its size, it requires attention only 2 to 3 times per year. Its top loading design allows you to inspect, remove and clean it without draining the spa.

5. SEATING AND LIGHTING.

The HOT SPRING SPA features a split level seating ring, built deep for comfortable reclining and total immersion (I). The barrier-free design eliminates the cramped, confined feeling of bucket seats, and allows you to move easily from fixed jets to moving jets or parts in between. The wide resting rim (J) provides an ideal perch for cooling off, or a safety bench for children. The HOT SPRING SPA also features an oversized underwater light with dimmer (K). Colored bulbs can be interchanged quickly and safely to create different effects.

6. NO INSTALLATION.

Simplicity of installation should be checked. An in-ground spa is the most difficult, requiring backyard excavation, building permits and an expensive installation crew. Permanently wired 220v., and gas units are not much simpler, and completely eliminate the advantage of portability. The HOT SPRING SPA avoids these problems by requiring only common household current to operate (110v. dedicated 20 amp.) (L). Just fill it up and plug it in. Its unique "treated grid" system requires no specific foundation for set-up and, as a portable appliance, you can take the HOT SPRING SPA with you when you move.

7. LISTED BY UNDERWRITERS LABORATORIES.

The HOT SPRING SPA is completely listed by Underwriters Laboratories, the recognized experts in testing for safety. The importance of correct and safe electrical design should not be overlooked. Check for the U.L. Mark on the outside of any spa you're considering - you'll see it on the HOT SPRING SPA.

We are proud of the quality features and performance we build into every HOT SPRING SPA. Each HOT SPRING SPA is an integrated design whose form follows function - the result of 10 years' evolution toward an ideal. So, before you buy any spa by any other name, see and test the HOT SPRING SPA. It's not the same.



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What's New in Photography

BY ARTHUR FISHER

Throwaway I

Eastman Kodak's Fling is a disposable camera—a 24-exposure 110 Kodacolor film cartridge wrapped in a fling-away housing, with a 25-mm f/8 lens, simple $\frac{1}{120}$ -sec. shutter, and manual film advance. It's aimed at impulse buyers at amusement parks and beaches. Under \$7.



Heavy-duty case

Aerospace cases are made from the same thermoplastic resin used in Ford's Taurus and Sable bumpers for maximum impact resistance. They are watertight and airtight. Carts and dollies are also available. Andiamo, Box 8415, Fountain Valley, Calif. 92728; from \$230.

Auto-bracketing SLR

The Contax 167 MT is a 35-mm single-lens-reflex camera with an unusual fillip: It provides built-in automatic bracketing. The camera will take normal, under-, and over-exposures in 1 sec., at one-half- to two-stop increments. List price (for the body only) is \$725.



Throwaway II

Like the Kodak Fling above, the Fuji Quick Snap wraps a disposable camera around a 24-exposure film cartridge—but Fuji's approach uses 35-mm film, not 110. And like the Fling, it is meant for outdoor sunlit shooting; the shutter speed is $\frac{1}{100}$ sec. Price: less than \$10.

Autofocus SLR

Latest to join the auto-everything SLR bandwagon is the Pentax SF1. In addition to the usual goodies, it has a built-in pop-up flash with through-the-lens metering. Pentax is also introducing nine autofocus lenses for the SF1, including a 70-210-mm zoom. Prices are not yet set.



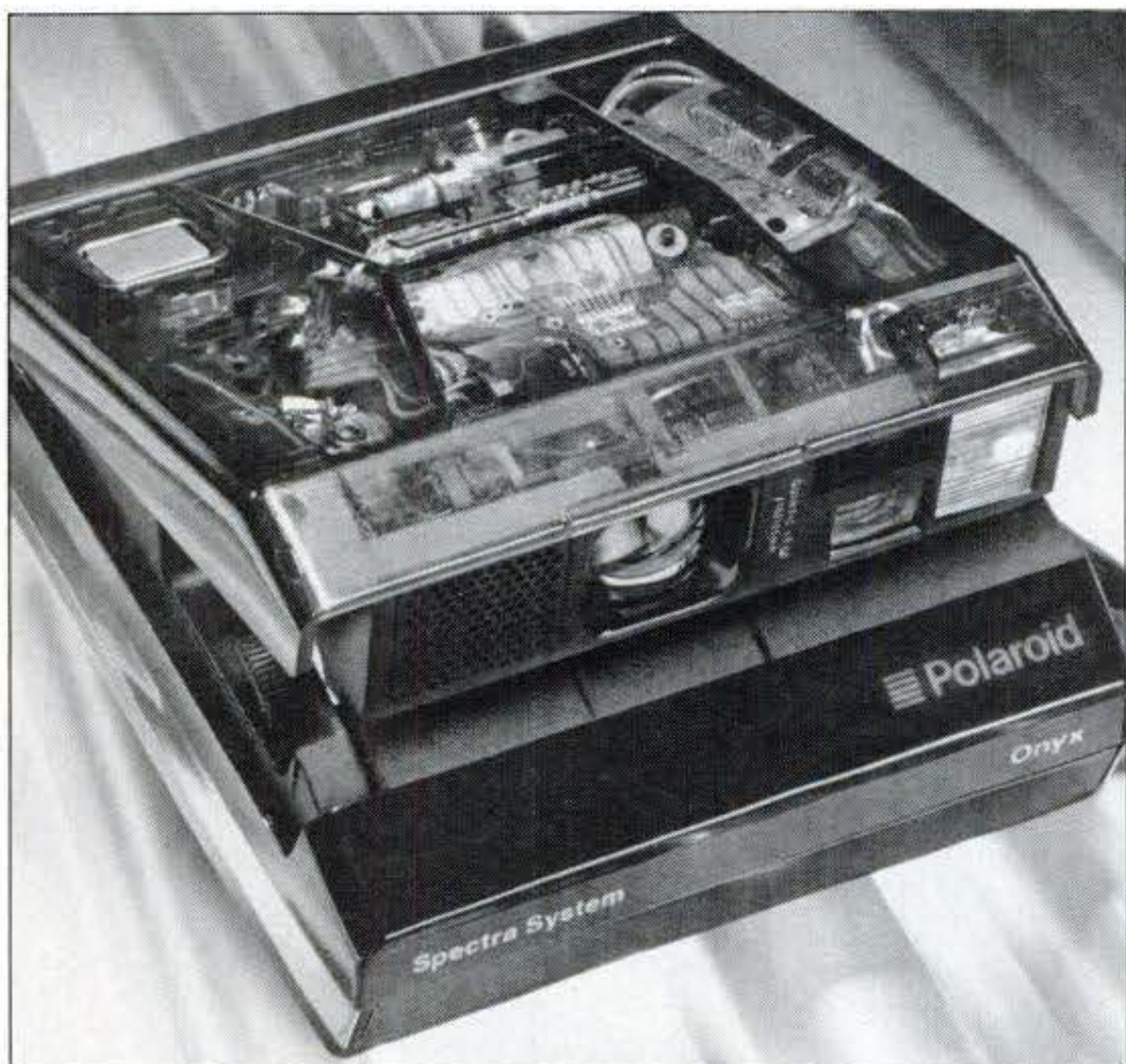


Fast telephoto

A boon to sports and nature photographers and photo-journalists, this Leitz APO-Telyt-R 280-mm f/2.8 lens focuses to a close 8.2 ft. It allows the camera to swivel for either vertical or horizontal shots. With a protective filter, palm grip, and metal case, it's \$6,402.

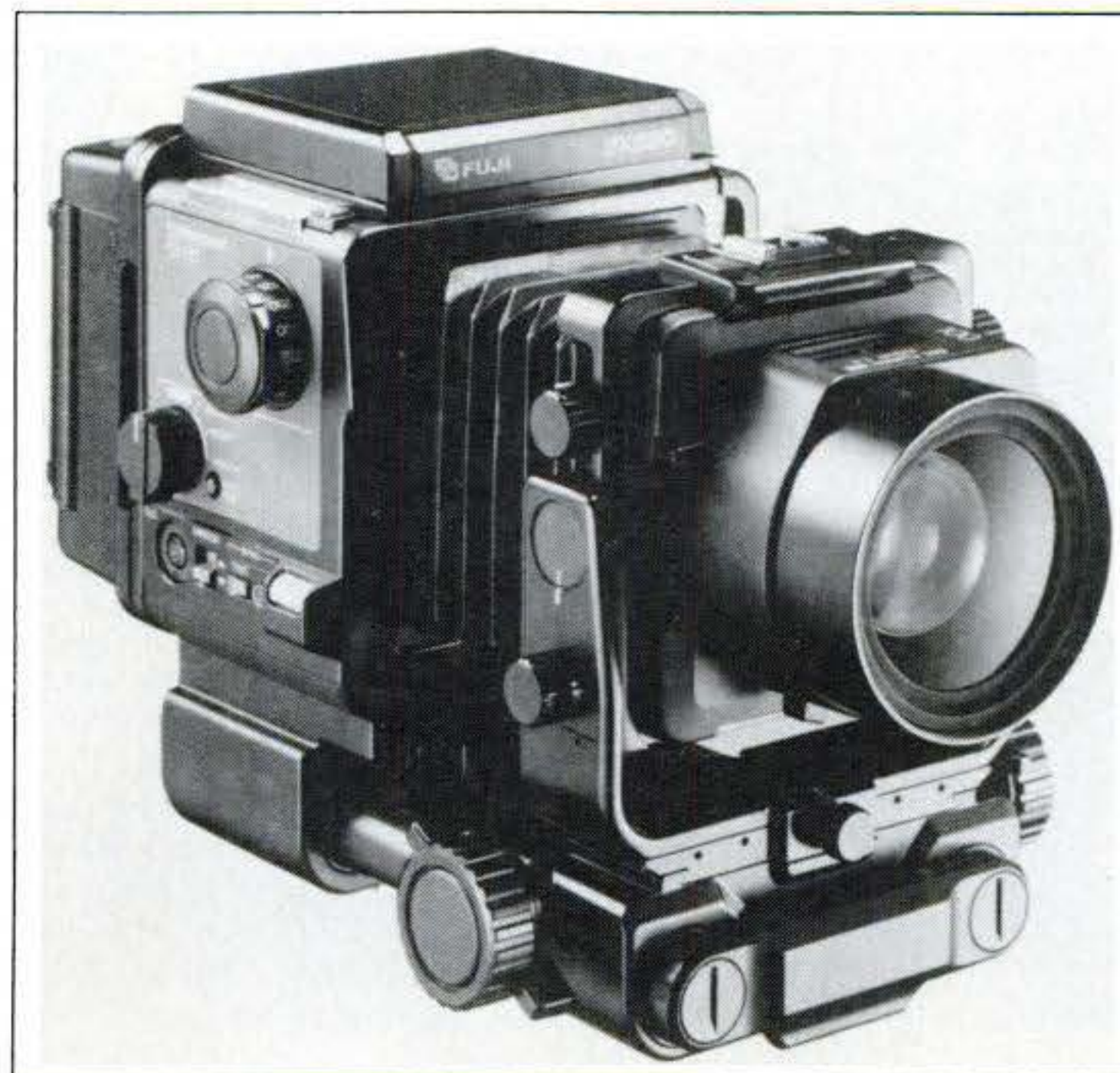
Versatile brackets

New Strobiframe Quick Flip flash brackets are available in models for 35-mm and medium-format cameras. They use a pivoting arm that keeps the flash above the lens in horizontal and vertical shots. The Saunders Group, 67 Deep Rock Rd., Rochester, N.Y. 14624; \$45.



See-through instant

Billed as "the world's first transparent camera," Polaroid's Onyx model of the Spectra system instant film camera lets the photographer who has everything watch what goes on inside as the camera makes more than 30 complex focusing and exposure decisions within $\frac{1}{50,000}$ sec. The Onyx uses the rectangular-format film first introduced with the Spectra. Its features include sonar autofocus, a built-in programmed flash that recharges in as little as $\frac{1}{5}$ sec., auto exposure control, and auto film advance. Price is \$280, or \$350 for a kit including accessories.



Dual-purpose tele

This Ricoh 500-mm mirror telephoto lens doubles as a high-powered spotting scope off the camera with the simple addition of an auxiliary eyepiece. It has a fixed f/8 aperture and focuses to $6\frac{1}{2}$ ft. Just 5.3 in. long, it weighs 28 oz. Price: \$485.

Swing-shift SLR

Fuji's GX680 medium-format (6-by-8-cm) camera has a built-in front bellows that provides full lens movement, with tilt and swing, shift, and rise and fall. It has through-the-lens metering and an electronically controlled shutter. It's \$2,488 with a 135-mm f/5.6 lens.

What's New for Your Car

BY JACK KEEBLER

Car scrubber

Water pressure powers the soft rotating bristles of the Swirlon Mark II System. The head has an 11-way adjustable neck, a removable soap reservoir, and an on/off control valve. Intermark World Products, Ltd., 630 Green Bay Rd., Kenilworth, Ill. 60043; \$30.



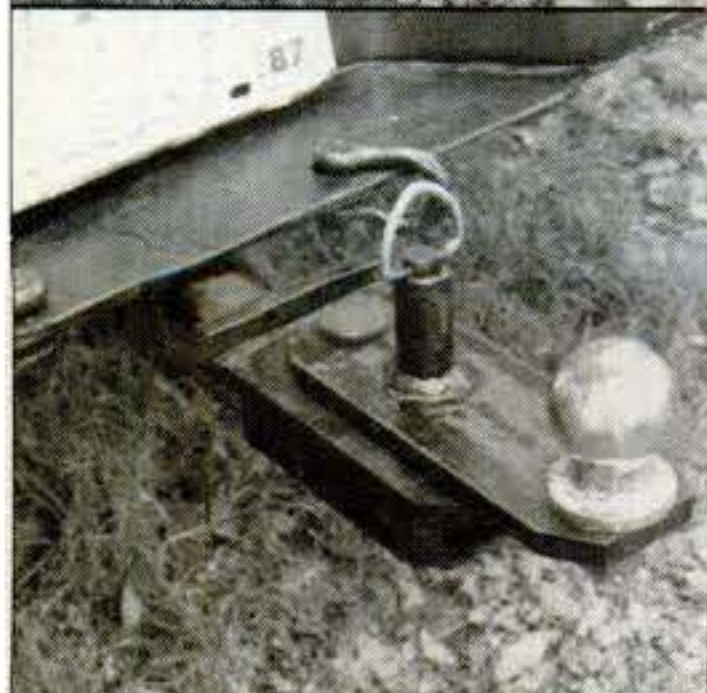
Helpful hitch

Trigger Hitch swings to the left or right for up to 13 in. of movement and slides forward and backward up to 7 in. Once the trailer is hooked up, you drive forward. The hitch locks into position as the pulling begins. Trigger Hitch Co., 606 Canal St., Delcambre, La. 70528; \$160.



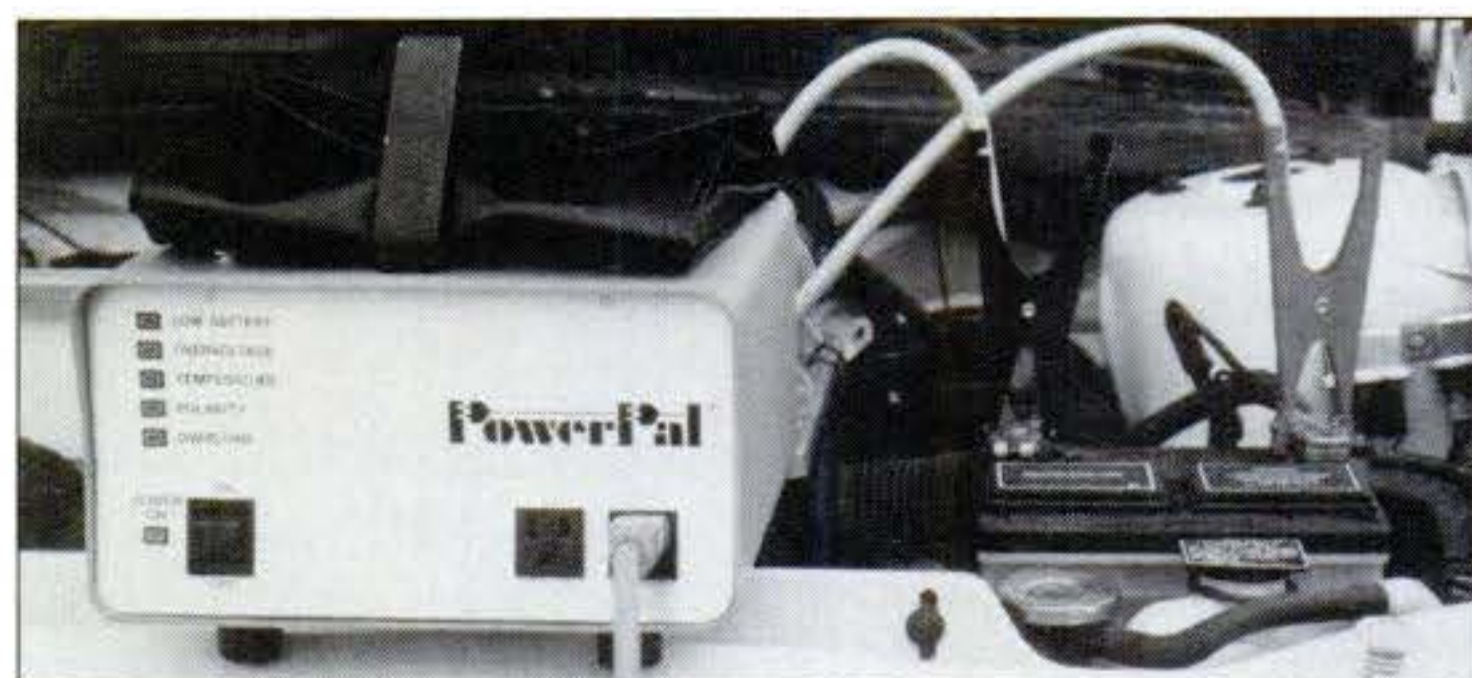
FM signal sender

Plug Sound Sender into the cigarette lighter, and any portable cassette or compact-disc player sends the player's sound through the vehicle's FM radio. It retails for about \$30. Dynasound Organizer, Div. of Hartzell Mfg., 2516 Wabash Ave., St. Paul, Minn. 55114.



Bed box

Pickup beds lack the security for expensive hand tools and materials. A Delta Classic steel bed box (\$90) can provide lockable weather-proof storage, a sliding organizer tray, and a black-baked-enamel finish. Delta Inc. of Arkansas, Box 3098, Jonesboro, Ark. 72403-3098.



Portable AC power

The PowerPal inverter clips to a vehicle's battery for 1,200 watts of continuous power (up to 4,800 watts in a surge) at 115 volts AC and 60 Hz. It has a low-battery shut-off and overload shut-down. PowerStar Products, 10011 N. Foothill Blvd., Cupertino, Calif. 95014; \$600.

Buckle up — for life!



AT \$6299*, YOU'LL HAVE PLENTY OF MONEY LEFT OVER TO FILL IT UP.

At a price of only \$6299*, the Isuzu P'UP is the lowest priced import truck in America.†

But about the only place we made compromises was the price.

We certainly didn't cave in when it came to the payload. It's capable of carrying over 1,100 pounds, more than enough to handle anything from a load of bricks to a loaded motorcycle.

And when it came time to make it rugged, our standards got tougher. For more than 73 years, our trucks have conquered Mexican deserts, African jungles, Arctic

blizzards and Moroccan sand and we don't intend to let them start slipping now.

Nor did we sit back when it came to the cab. That's why its interior appointments seem to be "almost custom installed" according to the editors at *Road and Track*.**

So while you're getting America's lowest priced import truck when you buy a P'UP, you should always keep one thing in mind. It didn't come cheap.

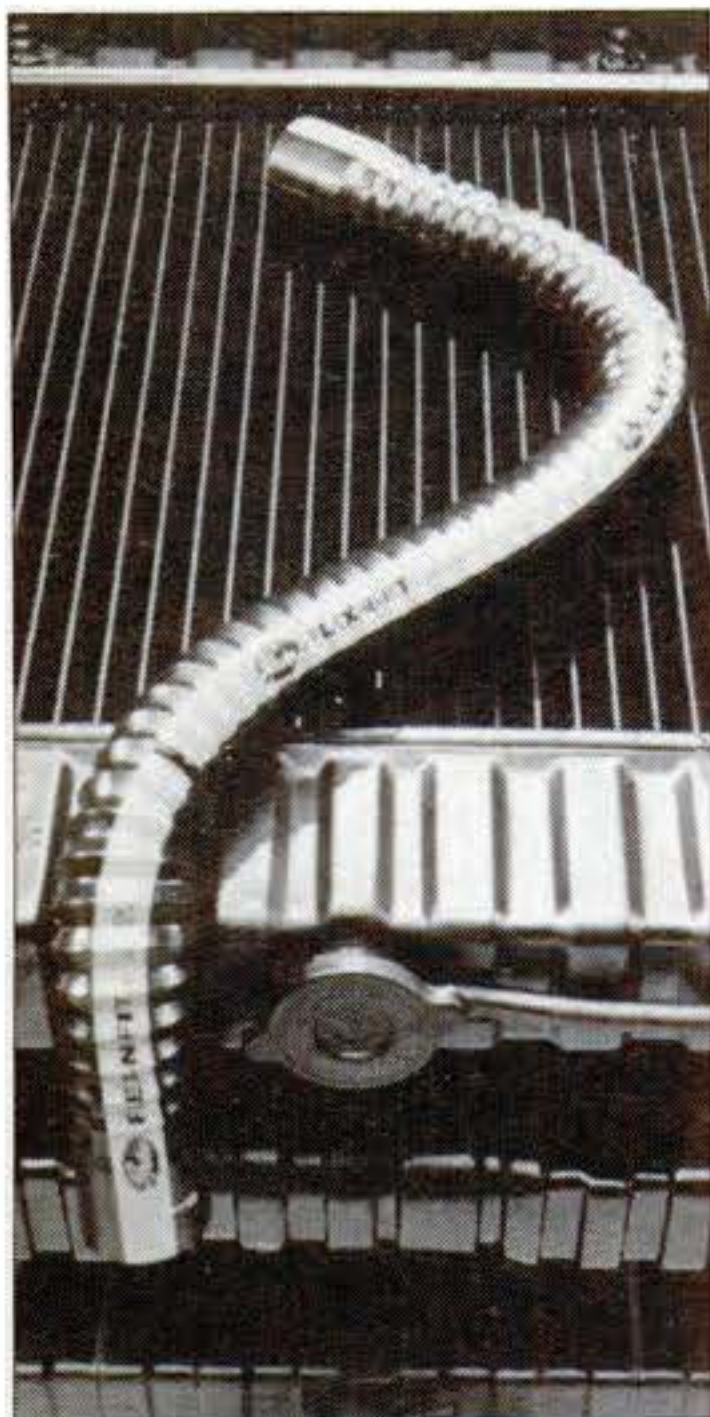


*Manufacturer's suggested retail price P.O.E. excluding tax, license and transportation fee. Price as of 3/1/87 and is subject to change. †Except Hawaii. ** *Road and Track Truck Buyer's Guide*, 1987.

The First Car Builders of Japan.

ISUZU

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◁ Handy hose

Gates Rubber Co. has introduced a radiator hose with an internal steel spine wire that retains the shape of the hose once it's formed. Gates claims the user can shape the hose to a 90° bend radius without fear of hose collapse. It comes in 13- to 48-in. lengths; \$9 to \$12.

Go-anywhere tire

Michelin has designed a new tire to deliver outstanding off-road performance without the noise, sloppy handling, and premature wear of off-road tires. The XC All Terrain features self-cleaning lugs, blocked shoulders, and a cut-resistant compound. \$100-\$150.



◁ Sliding-bed access

Bed-Sled is an aluminum roller-track system that provides a sliding pickup or van floor for easy access to loaded items. The maker claims it will support a load of up to 750 lbs. at the end. Davison-Wood, 5055 N. Harbor Dr., Suite H, San Diego, Calif. 92106; \$265 to \$439.

⌘ Anti-theft brakes

Quadra Lock's brake-line valve can stop a thief. Turn the key to the "on" position, and depress the brake pedal: Hydraulic pressure goes out from the master cylinder but can't return, locking all four brakes. Guardian Systems, 1635 W. Whittier Blvd., Montebello, Calif. 90640; \$259.

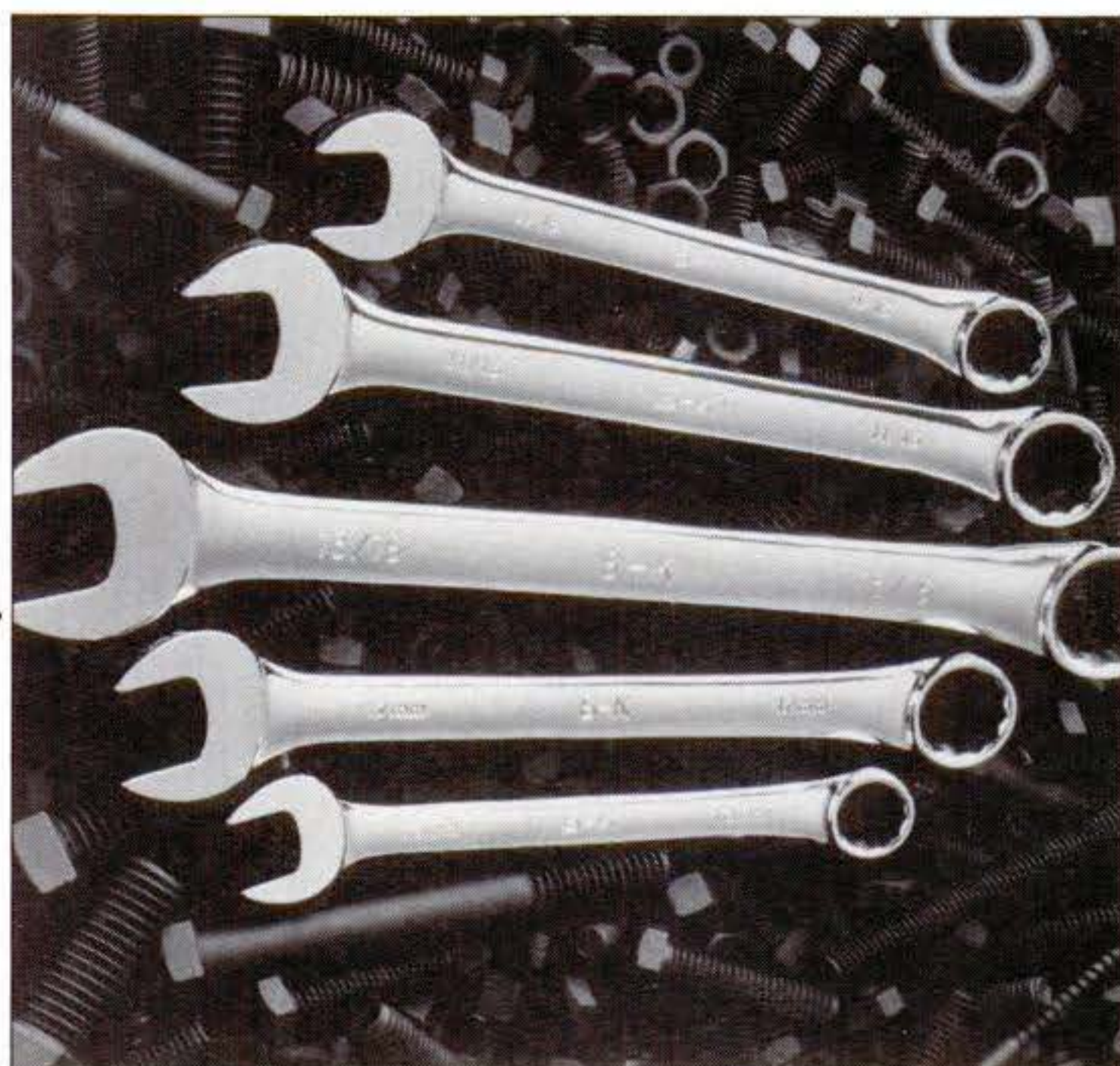


◁ High-speed retread

The remanufactured M+S Achievor radial from Sears carries an "H" rating for safe performance at track speeds of up to 130 mph. The computer-inspected tire has a 30,000-mile warranty and smooth-riding rubber compound, and comes in 10 sizes (\$44-\$55) to fit most cars.

Tougher tools

SuperKrome wrenches from SK Hand Tool Corp. (Chicago, Ill.) are hot forged from high-grade steel and are said to be up to 30% stronger than premium industrial and automotive brands. Available in metric or English, they come in 7- and 15-piece sets (\$36 and \$95).





When ESCORT was introduced in 1978, its radar warning was merely astonishing. Then the improvements began:

"If you can imagine the Turbo Porsche of the radar detectors, this is it!" That was *Car and Driver's* verdict on the first ESCORT.

The comment referred to ESCORT's astonishing performance, but it anticipated something more. Just as Porsche keeps refining its classic 911, our engineers now have nine years of technical advancements built into ESCORT.

More power under the hood

While car makers talk about horsepower, engineers measure a detector's radar-finding ability in dB. Today's ESCORT is significantly more powerful than the one that drew superlatives from *Car and Driver* nine years ago: 10 dB more sensitive on X band, 13 dB on K band.

Our engineers never stop researching, and when they make a breakthrough, it goes into production immediately. Consequently, ESCORT performance is always at the forefront. In its most recent test of ESCORT, *Road & Track* wrote, "... it is highly recommended."

Since then, our engineers have added an extra 2 dB to ESCORT's sensitivity on both bands. Imagine what *Road & Track* would say now.

Rashid rejection too

Of course, there's more to detection than simply issuing a long-range warning. The warning must be real. No false alarms.

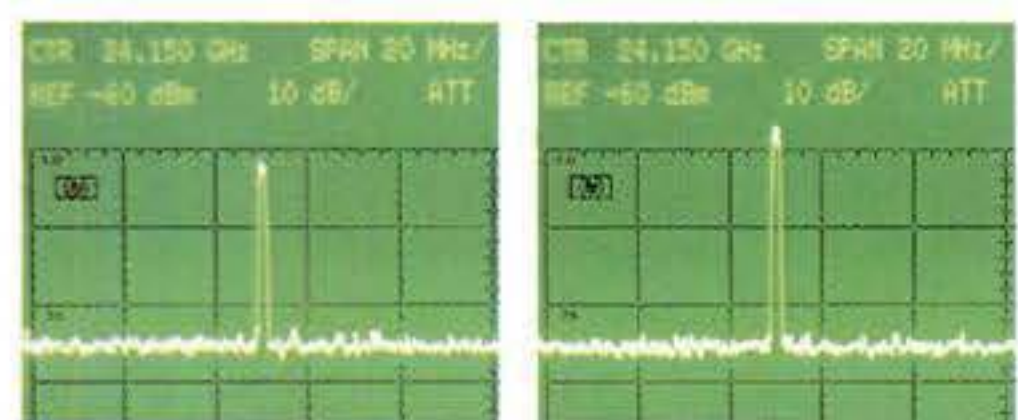


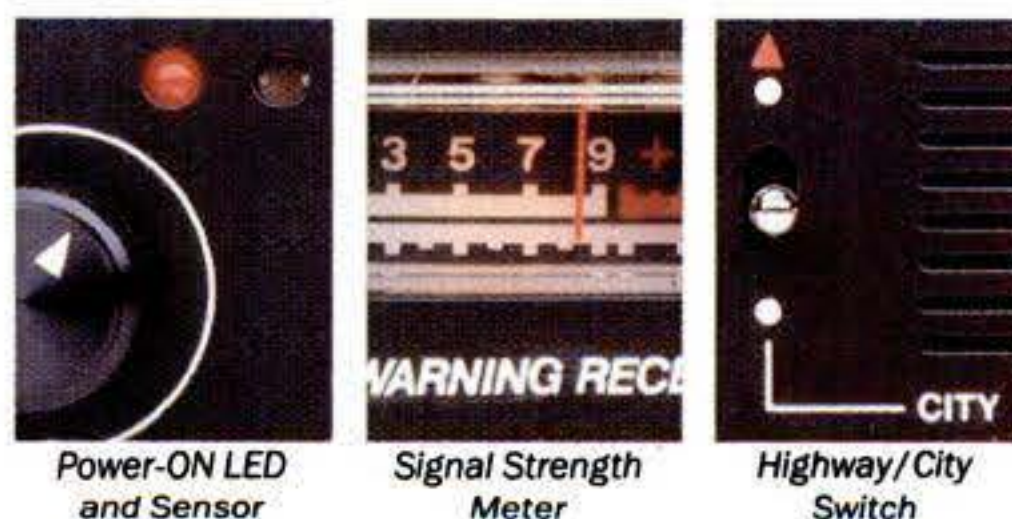
Figure 1: A digital spectrum analyzer scanning the entire width of K band can't see the difference between radar and Rashid.

When the FCC cleared the Rashid VRSS collision warning system for operation on K

band, there was no known way to distinguish between Rashid and radar. But our engineers came through again. Our AFR™ (Alternating Frequency Rejection) circuitry automatically isolates and neutralizes Rashid signals, yet leaves ESCORT's radar detection capability undiminished for your protection.

The full radar report

In addition to long-range warning, ESCORT also pioneered a full-disclosure warning system that tells you everything you need to know about the radar it finds. At first radar contact, the alert lamp responds and the analog meter indicates radar strength. Simultaneously you will hear an audio warning—pulsing slowly when radar is weak, quicker as you near, then constant as you approach range.



ESCORT also provides separate warning tones for each radar band. And we've added a Mute function for your convenience: once you've noted the warning, touching a switch mutes the audio warning, yet leaves the detection circuits fully armed for the next encounter.

Character reference

Our policy of continuous refinement has prompted the experts at *Road & Track* to say, "Externally, the ESCORT has changed hardly at all over the years; internally, it has undergone several major revisions, each establishing new performance standards in the field."

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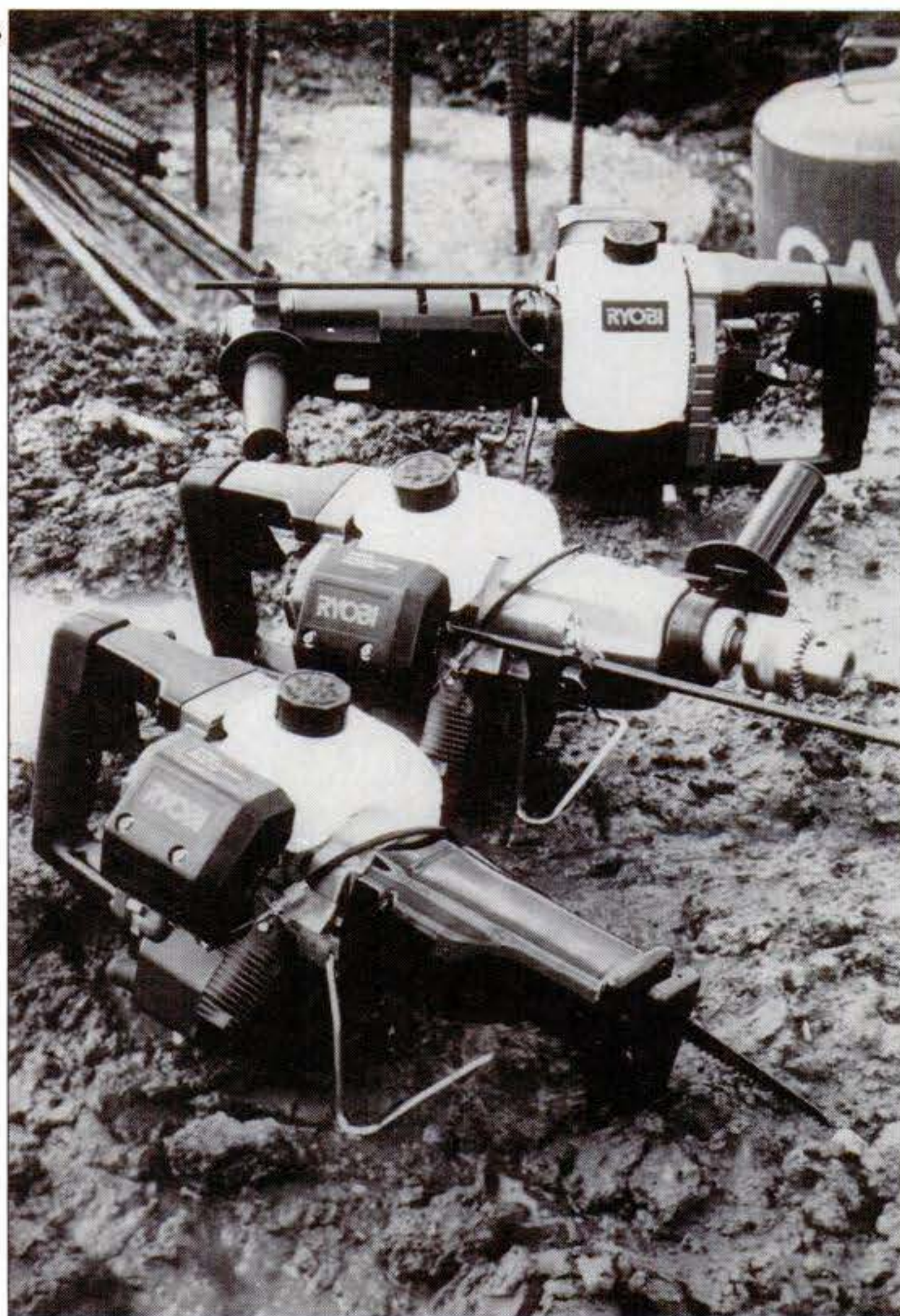
© 1987 Cincinnati Microwave, Inc.

What's New in Tools

BY V. ELAINE GILMORE

Fill 'er up?

New go-anywhere tools from Ryobi are powered by two-cycle gasoline engines. The trio includes a pneumatic rotary hammer (top, \$579), hammer drill (center, \$449), and reciprocating saw (\$449). Ryobi, 1158 Tower Lane, Bensenville, Ill. 60106.

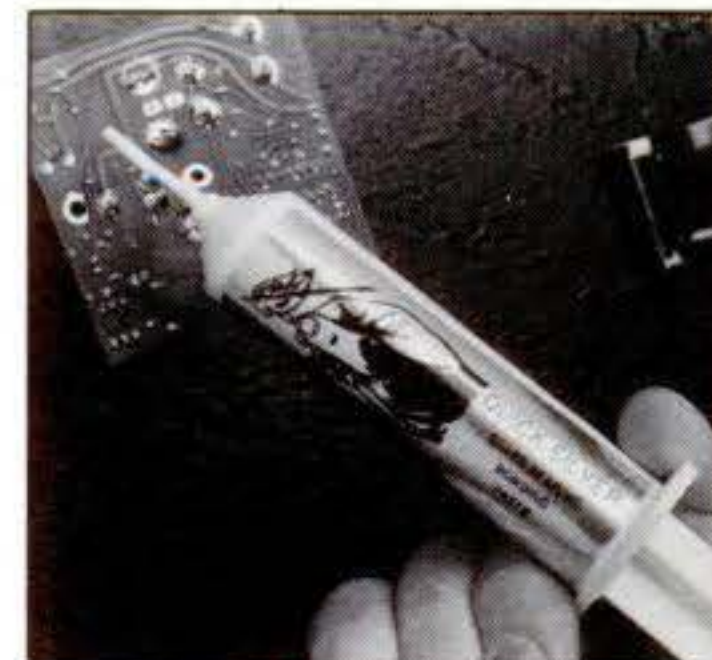


Cordless cutter

Cut drywall, carpet, sheathing, veneer, and more with the various blades of Hitachi's cordless knife cutter. The knife (\$179) cuts with an orbital action at 5,000 strokes per min. Its 9.6-V nicad battery recharges in 1 hr. Hitachi, 4487-F Park Dr., Norcross, Ga. 30093.

Drip stripper

Freshly painted walls... how nice. Paint drips on the carpet, smears on woodwork, spatters on the brick fireplace... how annoying. Now you can remove dried latex-paint drips with Klean-Clean, claims Klean-Strip (Box 1879, Memphis, Tenn. 38101). A 4-oz. can is \$2.59.



No torch needed

Quick Silver is a silver-bearing bonding paste that flows at 430° F. You squeeze it from a syringe, then heat it with a match, butane lighter, or soldering gun. It forms high-strength bonds with most metals. It's from E. L. Jones Co., Box 849, Sanford, N.C. 27330; \$12 (ppd.).



Big potential

Skil's newest cordless drill has a 12-V nicad battery (9.6-V or smaller is standard) and re-engineered motor that packs more power. The drill, due out next month, comes in a two-speed (\$150) and variable-speed (\$175) model. Both have reverse and five clutch settings.



Scraper/cutter

The Slam Scraper uses a sliding action to deliver up to 150 psi. It removes ice from sidewalks or ceramic tiles from floors, says the maker. With a second head, it removes linoleum or trims garden borders. Gray Mountain Tool Co., Box 94221, Pasadena, Calif. 91109; \$35.

Vision Break-through

When I put on the pair of glasses what I saw I could not believe. Nor will you.

By Joseph Sugarman

I am about to tell you a true story. If you believe me, you will be well rewarded. If you don't believe me, I will make it worth your while to change your mind. Let me explain.

Len is a friend of mine who knows good products. One day he called excited about a pair of sunglasses he owned. "It's so incredible," he said, "when you first look through a pair, you won't believe it."

"What will I see?" I asked. "What could be so incredible?"

Len continued, "When you put on these glasses, your vision improves. Objects appear sharper, more defined. Everything takes on an enhanced 3-D effect. And it's not my imagination. I just want you to see for yourself."

COULDN'T BELIEVE EYES

When I received the sunglasses and put them on I couldn't believe my eyes. I kept taking them off and putting them on to see if indeed what I was seeing was indeed actually sharper or if my imagination was playing tricks on me. But my vision improved. It was obvious. I kept putting on my \$100 pair of sunglasses and comparing them. They didn't compare. I was very impressed. Everything appeared sharper, more defined and indeed had a greater three dimensional look to it. But what did this product do that made my vision so much better? I found out.

The sunglasses (called BluBlockers) filter out the ultraviolet and blue spectrum light waves from the sun. You've often heard the color blue used for expressions of bad moods such as "blue Monday" or "I have the blues." Apparently, the color blue, for centuries, has been considered a rather depressing color.

For eyesight, blue is not a good color too. There are several reasons. First, the blue rays have one of the shortest wavelengths in the visible spectrum (red is the longest). As a result, the color blue will focus slightly in front of the retina which is the "focusing screen" in your eye. By blocking the blue from the sunlight through a special filtration process, and only letting those rays through that indeed focus clearly on the retina, objects appear to be sharper and clearer.

The second reason is even more impressive. It is harmful to have ultra-violet rays fall on our eyes. Recognized as bad

for skin, UV light is worse for eyes and is believed to play a role in many of today's eye diseases. In addition, people with contact lenses are at greater risk because contacts tend to magnify the light thus increasing the sun's harmful effects.

SUNGLASS DANGER

Finally, by eliminating the blue and UV light during the day, your night vision improves. The purple pigment in your eye, called Rhodopsin, is affected by blue and ultraviolet light and the eyes can take hours to recover from the damage.

But what really surprised me was the danger in conventional sunglasses. Our pupils close in bright light to limit the light entering the eye and open wider at night like the lens of an automatic camera. So when we put on sunglasses, although we reduce the amount of light that enters our eyes, our pupils open wider and we allow more of the harmful blue and ultraviolet light into our eyes.

DON'T BE CONFUSED

I'm often asked by people who read this, "Do those Blu-Blockers really work?" They really do and please give me the opportunity to prove it. I guarantee each pair of BluBlockers to perform exactly as I described.

BluBlocker sunglasses use ophthalmic-quality CR-39 lenses with a hard anti-scratch coating. Over 85 percent of all doctors' prescriptions are now filled with CR-39. No shortcuts were taken.

The black, light-weight anodized aluminum frame is one of the most comfortable I have ever worn and compares with many of the \$200 pairs you can buy from France or Italy.

The weakest link in any pair of glasses is the hinge. So there's a precision two-way tension hinge that not only bends when you close the pair, but is spring-loaded to bend outward too. You get a completely flexible frame that will comfortably contour to any size face.

There are also two other models. One is a clip-on pair that weighs less than one

ounce and fits over prescription lenses and the second is a precision-molded plastic frame that looks identical to the aluminum model but without the tension hinge. All models include a padded carrying case and a one-year limited warranty.

I urge you to order a pair and experience your improved vision. Then take your old sunglasses and compare them to the BluBlocker sunglasses. See how much clearer and sharper objects appear with the BluBlocker pair. And see if your night vision doesn't improve as a direct result. If you don't see a dramatic difference in your vision—one so noticeable that you can tell immediately, then send them back anytime within 30 days and I will send you a prompt and courteous refund.

DRAMATIC DIFFERENCE

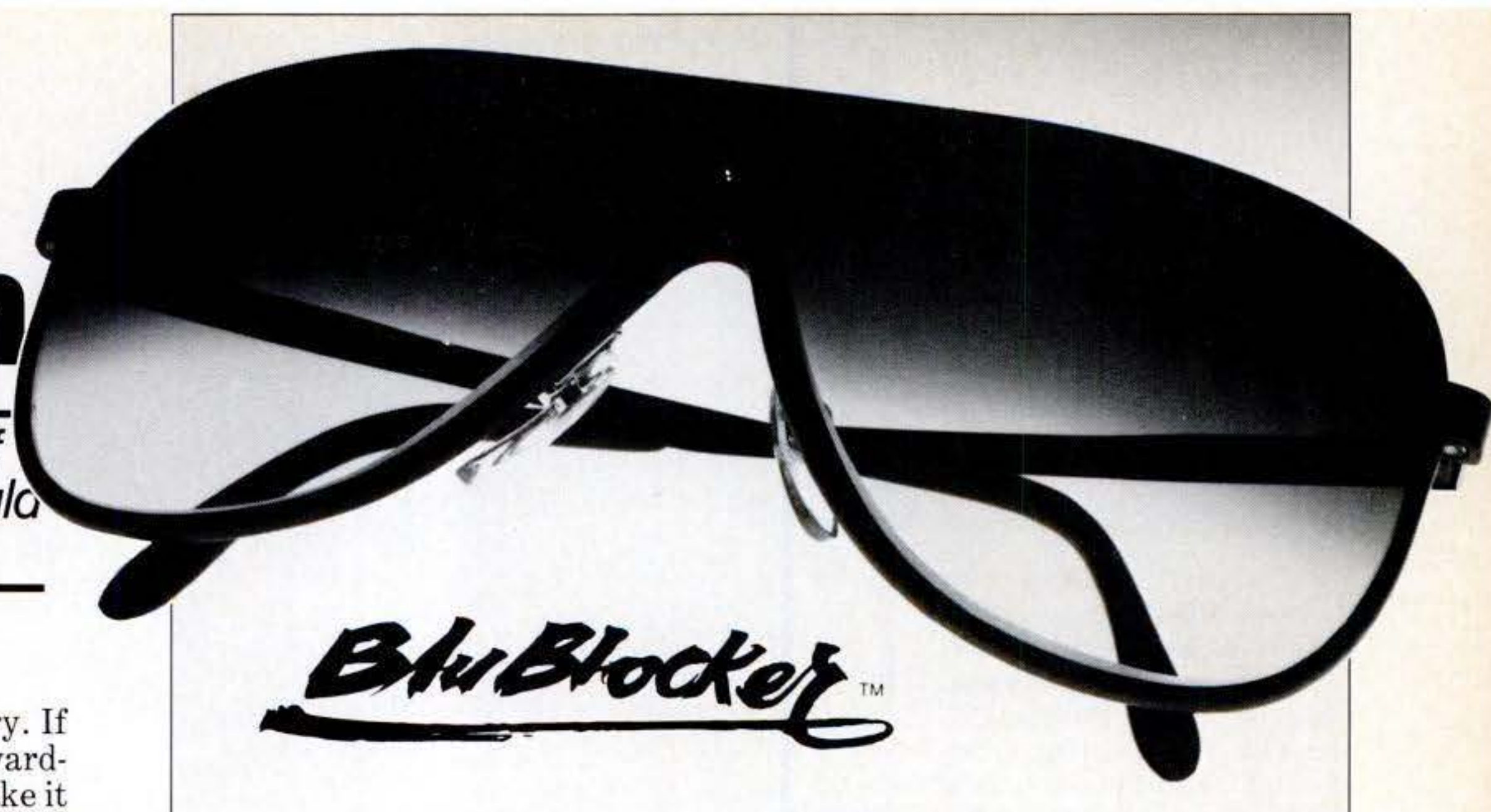
But from what I've personally witnessed, once you wear a pair, there will be no way you'll want to return it.

Pilots, golfers, hunters, athletes and anyone who spends a great deal of time in the sun, who drives a car or who just wants to protect their vision—all will find BluBlocker sunglasses indispensable.

Our eyes are very important to us. Protect them and at the same time improve your vision with the most incredible breakthrough in sunglasses since they were first introduced. Order a pair or two at no obligation, today.

Credit card holders call toll free and order by product number below or send a check plus \$3 for postage and handling.

Aluminum Deluxe (0029HW) . . .	\$69.95
Clip-On Model (0028HW)	29.95
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What's New in Electronics

BY WILLIAM J. HAWKINS

Smart remote

This remote control can mimic—and replace—individual remotes for hi-fi, TV, or satellite TV receivers. Made by R. L. Drake Co. (Box 112, Miamisburg, Ohio 45342), it controls Drake's satellite receivers but can be programmed for any brand. Price: \$130.



Power watcher

Designed to indicate current failure quickly, Current Ring slips over an AC power wire and glows as long as 2 amps or more are flowing. The device requires no splices or connections. Made by Current Ring Co., Box 1525, Ballwin, Mo. 63022; \$11.45 for 10.



Wireless hi-fi

Attach an infrared transmitter to your hi-fi to hear high-quality audio (20–20,000 Hz) via a special receiver. The wireless earphone system has controls for volume, noise reduction, and bass boost. Koss Corp., 4129 N. Port Washington Ave., Milwaukee, Wis. 53212; \$120.

Built-in VCR

GoldStar's 19-in. ViewMax TV has a VCR built in. The front slot accepts T-160 VHS tapes for up to 8 hrs. of recording time. The TV has 105-channel capability with 12 channel presets and remote control. GoldStar Electronics Intl., 1050 Wall St. W., Lyndhurst, N.J. 07071; \$650.



Close-up camcorder

The autofocus system on the Series-C3300 VHS-C camcorder lets you take sharp pictures of objects that are as close as the front of the lens, says Minolta. It uses a through-the-lens phase-detection system to determine distance. Price is not yet set.

TV receiver

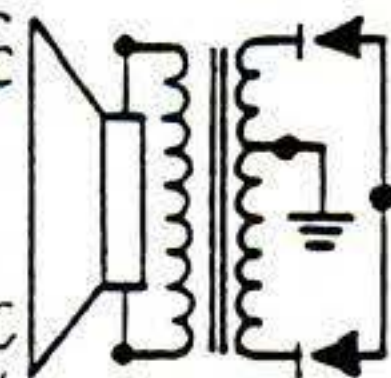
It's a stereo receiver, complete with speakers, but the V-7640 is made for TV. The cable-ready unit contains an amplifier and MTS decoder for listening to stereo broadcasts. Made by Universal Security Instruments (10324 S. Dolfield Rd., Owings Mills, Md. 21117), it's \$269.

Increase your knowledge about all aspects of electronics

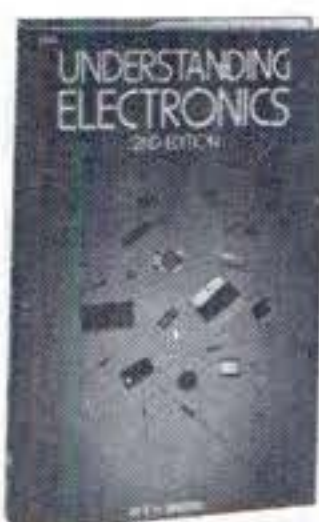
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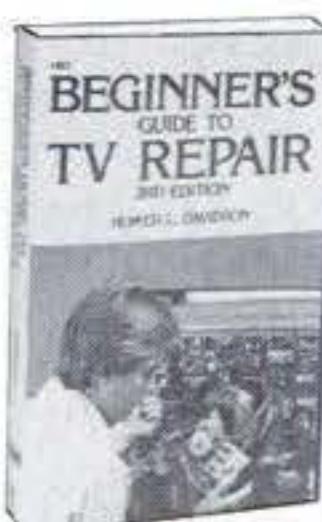
values
to
\$128.80



2625 \$23.95



1553 \$15.95



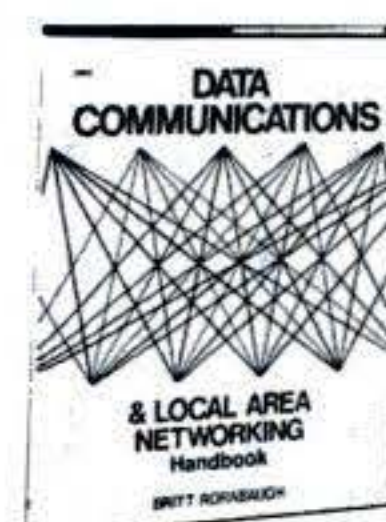
1897P \$13.95



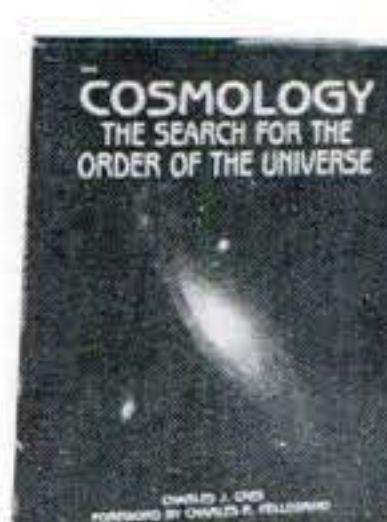
1734 \$18.95



1870 \$19.95



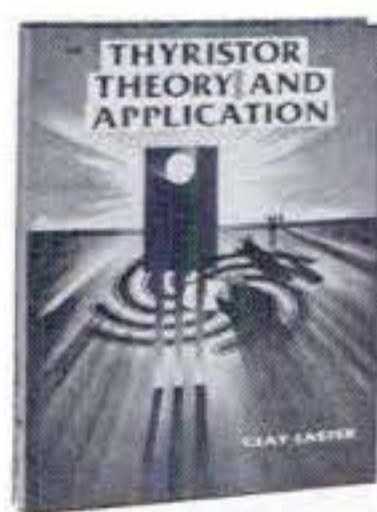
2603 \$25.00



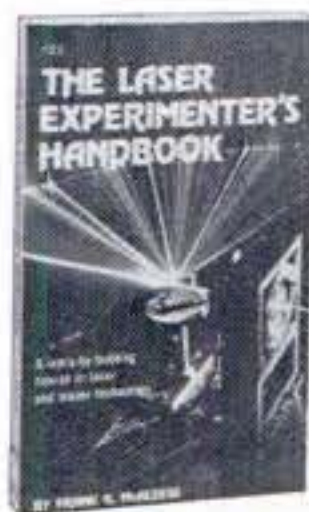
2626 \$16.95



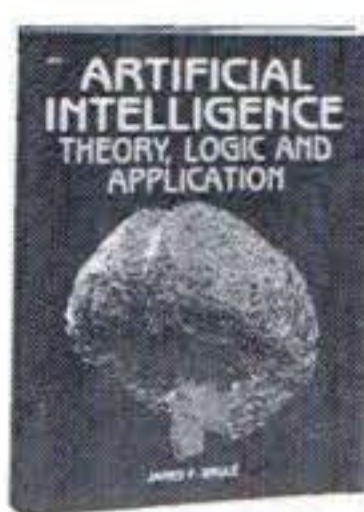
1625 \$24.95



2665 \$17.95



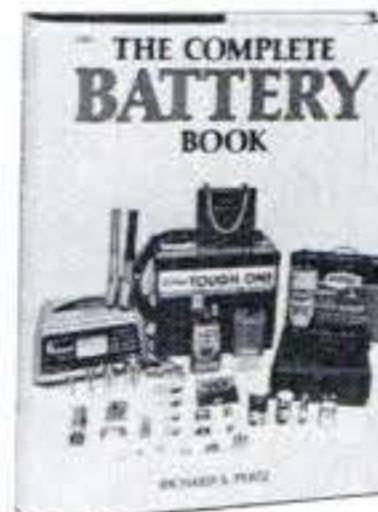
1123P \$9.95



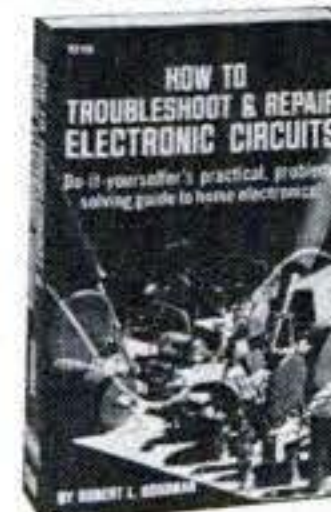
2671 \$18.95



1492 \$14.95



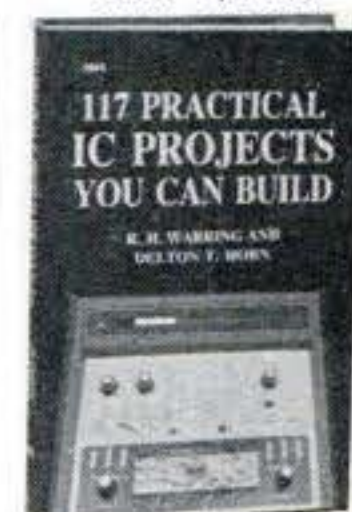
1757 \$24.95



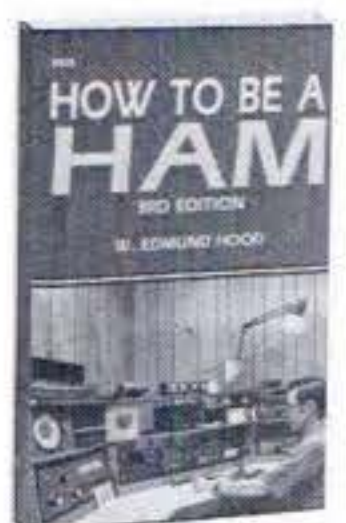
1218P \$13.95



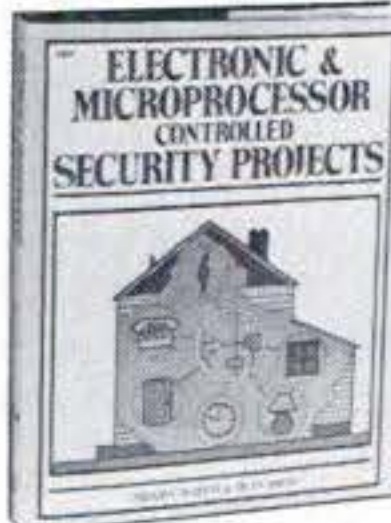
1858 \$16.95



2645 \$16.95



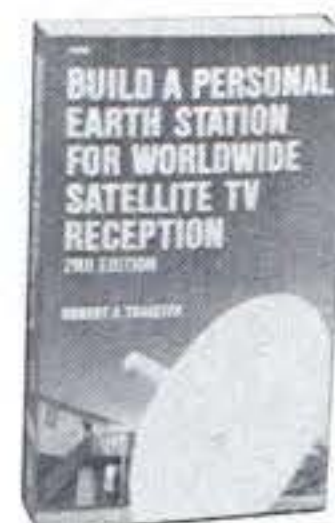
2653P \$12.95



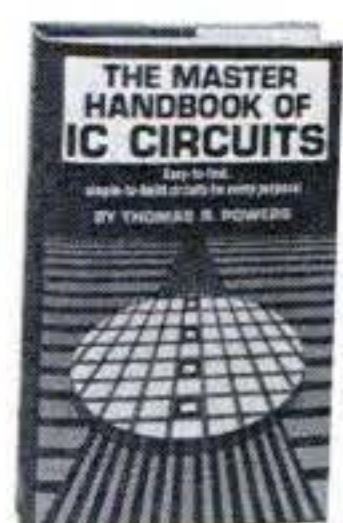
1957 \$21.95



2795 \$29.95
Counts as 2



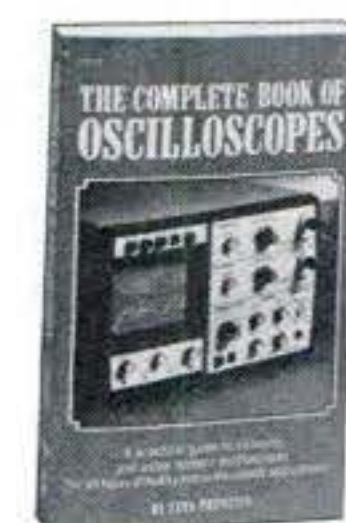
1909P \$14.95



1370 \$26.95



2753 \$23.95



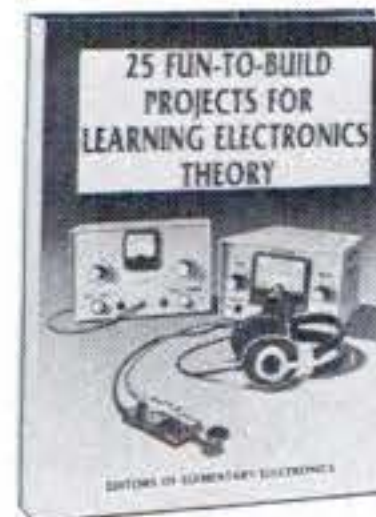
1532P \$14.95



1999 \$21.95



2790 \$18.95



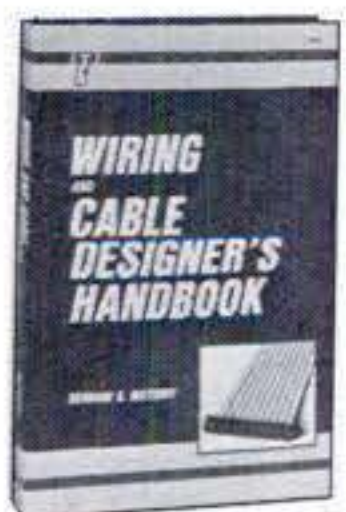
2839 \$15.95



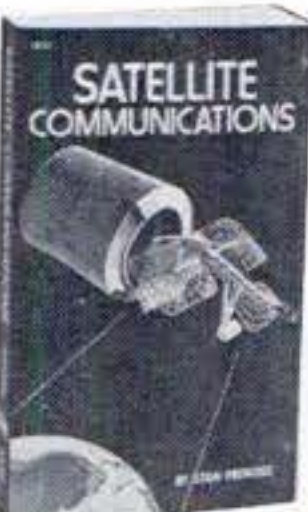
1277P \$15.95



2715 \$16.95



2720 \$32.50
Counts as 2



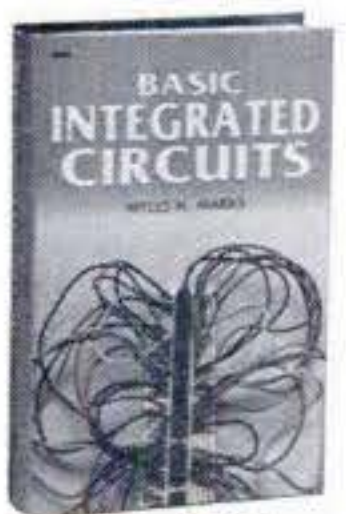
1632P \$12.95



2657 \$32.50
Counts as 2



1604P \$15.95



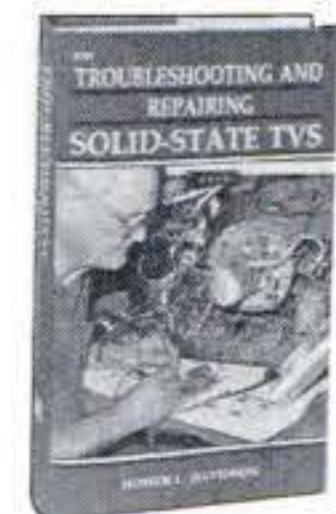
2609 \$26.95



2755 \$17.95



1996P \$11.95



2707 \$24.95

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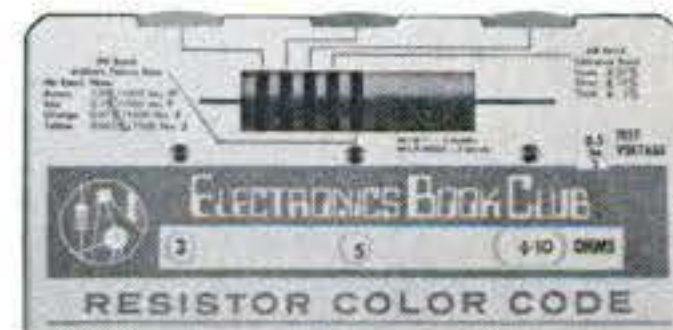
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Frozen tools [Continued from page 67]

cryogenically treated. Without exception, the treated balls, coded by number, were driven twenty to forty yards farther," Norian told me.

Materials Improvement's Busch treats plastic that is turned into contact lenses. Elliot Pucker, president of Amcry, has treated nylon stockings and panty hose. Women who have had their nylons frozen report dramatic results. One claims she gets an extra three months' wear out of every pair.

Stocking wearers and golfers may try cryogenic treatment based on hearsay, but big companies invariably run controlled comparison tests, generally on computerized numerically controlled machines, which eliminate the human factor. Often the companies run blind tests, with the machine operators and those keeping track of tool usage unaware there's a test.

In addition, extensive laboratory tests have been done by mechanical engineering professor Dr. Randall F. Barron at Louisiana Tech University in Ruston, La. Those tests, too, have confirmed the benefits of freezing on most alloy steels. In one series of tests Barron compared five common steel alloys. First, he tested them as bought. Then he chilled them to -120 degrees F. Finally, he chilled them to -320 degrees F. In all cases the cold treatment enhanced wear resistance—and the colder, the better, he found. The -120-degree treatment improved wear resistance by ratios ranging from 1.2 to 2, depending on the alloy. The -320-degree soak improved wear resistance by ratios ranging from 2 to 6.6.

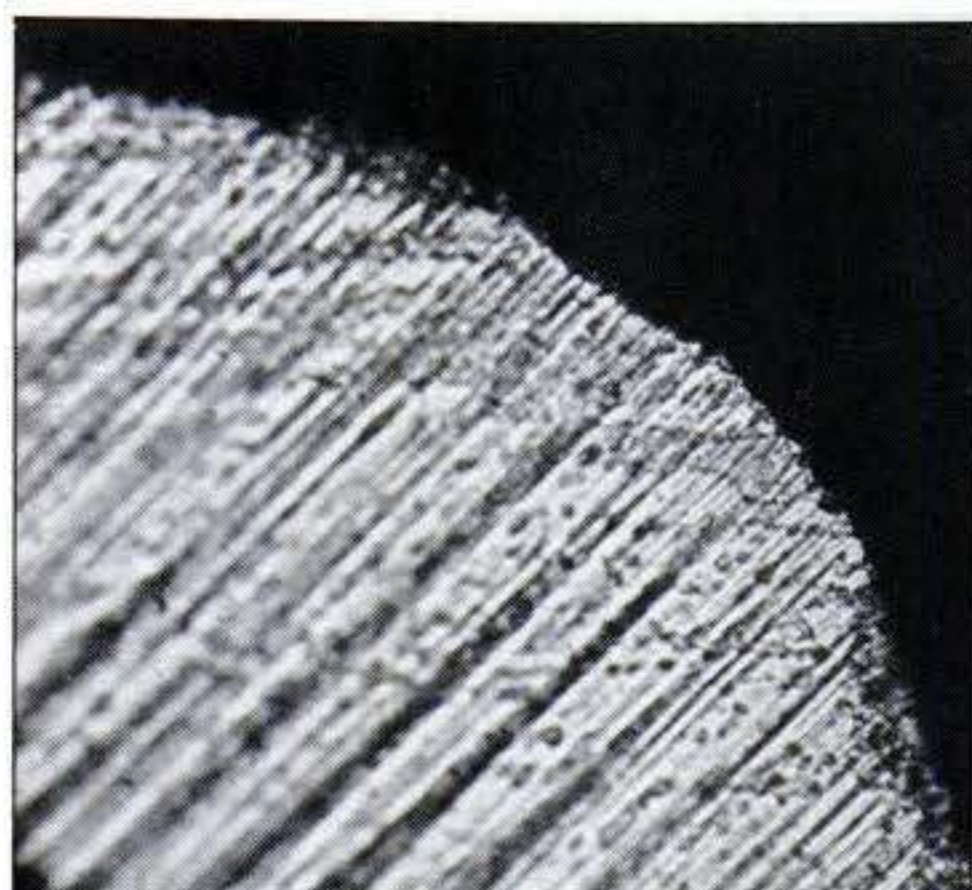
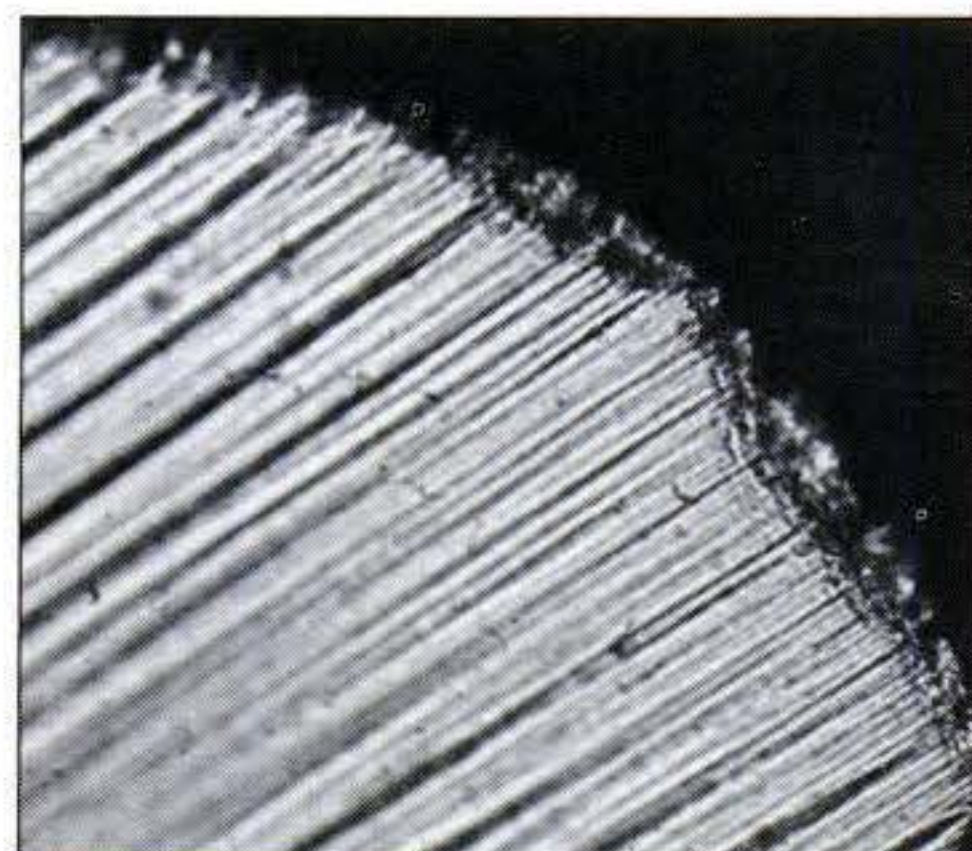
The down side

If cryogenic treatment is so good—and relatively cheap—why isn't it universally applied?

For one thing, it doesn't always work; and when it will work is not always predictable. The American Iron and Steel Institute, a membership organization in Washington, D.C., that represents most of the country's steel makers, maintains that if a steel is properly heat-treated, cryogenic treatment can do nothing to improve it. Maurice DeWalt is chairman of that organization's tool-steel committee and chief metallurgist at Braeburn Alloy Steel in Lower Burrell, Pa. "A few of our customers tried cryogenic treatment some years ago," DeWalt said, "and they found no improvement."

To see whether cryogenic treatment had any detectable effect on home-workshop tools, *POPULAR SCIENCE* devised its own tests, with disappointing results (see sidebar).

Even more problematic than the fact that cryogenic treatment does not al-



Photomicrographs of scalpel edges show that cryogenically treated steel (above) can be sharpened to a finer edge than can untreated steel (top). One reason, say experts: The microstructure is more homogeneous. Another reason: Residual stresses, which can cause chipping upon grinding, are relieved. Photos: Applied Cryogenics.

ways work is a lack of solid scientific research: No one knows for sure why deep-freezing might cause such benefits in the first place.

"Rigorous scientific investigations of the mechanisms involved just haven't been done," says Dr. Charles Marschall, a senior research scientist in the physical metallurgy section of Battelle's Columbus, Ohio, laboratory. Marschall has a proposal out now soliciting funds for a study that would attempt to predict performance improvements after cryogenic treatment and investigate the mechanisms involved.

In general, metallurgists put more credence in claims that steel is improved by cryogenic treatment than they do in such claims for other materials. The standard theory espoused concerns the fact that the cold temperatures cause one form of crystalline steel, called austenite, to transform to another, called martensite (see caption and drawings).

Conventional steel metallurgy is based on this transformation. "In its annealed state, steel is soft and malleable. You can machine and form it," Levine explained. "Then by heating it sufficiently, it can be put into the

austenitic state. Subsequent rapid cooling, or quenching, of the austenite triggers a transformation to martensite, which is hard and abrasion-resistant.

"But even after quenching, you have some small amount of retained austenite—which is soft and easily abraded," Levine went on. "Traditionally, the hot metal is quenched to room temperature.

"But there's nothing sacred about room temperature," he declared excitedly. (Both the pitch and volume of his voice rise when he makes big points.) "As long ago as the forties, Dr. Morris Cohen, a noted metallurgist at MIT, observed that more austenite is transformed if you chill the steel below room temperature," Levine related. Others have confirmed, through X-ray diffraction and other means, that cryogenic treatment transforms some of the retained austenite to martensite.

There are limitations to this theory, however. One is this: Assuming they were properly heat-treated, the high-alloy steels used for tools won't have much retained austenite—maybe as little as two percent.

"If you start with only two percent retained austenite and end up with one percent, it is inconceivable to me that that could account for the enormous improvements that are often claimed," Marschall confided.

More carbides?

Barron offers a second theory to help explain why freezing improves steel. He investigated various alloys magnified 1,000 times under a light microscope and reported seeing fine carbide particles after the freeze. "These were much smaller than the original carbide particles present in both the treated and untreated samples," he told me.

How would additional carbide precipitation improve the performance? I asked that of Dr. Bruce Christ, a research metallurgist at the National Bureau of Standards in Boulder, Colo., who has had long involvement with metals and cryogenics. "When carbide precipitates form, the internal stress in the martensite is reduced," Christ explained. "That minimizes the susceptibility to micro-cracking. And the distribution of fine carbides, which are very hard, could also increase wear resistance."

But published research by other investigators has not confirmed Barron's observations. "I can see how carbides could precipitate when you bring the steel from cryogenic to room temperature," commented Christ. "But whether they do is still up for grabs."

Continued



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Frozen tools *Continued*

Still, neither a reduction of retained austenite nor more carbide particles could have anything to do with the improvements claimed for copper electrodes—or golf balls. "I've got to believe something else is happening," said Marschall. That something else may have to do with altering internal stresses in the materials.

Internal stresses are present in all metals, and are sometimes beneficial and sometimes damaging. Fractures and failures can start at areas of high stress concentration. One cause of stresses: Adjacent regions of a metal may not respond identically to temperature changes or other external forces. Thus mechanical and thermal treatments are used to alter stresses.

How could freezing alter the stresses? "Perhaps it's as simple as differential thermal expansion," Marschall offered. "Three popular brands of copper electrodes I've investigated have had hard particles dispersed in the copper," he related. "Those particles have a much lower thermal-expansion coefficient than the copper. As the temperature drops, the copper contracts more than the particles and pinches in on them, developing a tensile stress in the copper at the junctures.

"If that tensile stress gets high enough, it can actually cause plastic deformation," he continued. The crystals will deform. "That can give rise to a residual stress when you take the metal back to room temperature; or if there was a stress present originally, it will change that stress." A similar phenomenon could occur in cemented carbides and in other metals.

Cold relief

Theoretically, the cold could either relieve or intensify stresses. "My observations have always indicated stress relief," Levine stated.

Those observations are based on quite a different application of cryogenic processing: It is frequently used to stabilize the dimensions of metals. Tom Willis, the motorcycle racer, had Amcry Corp. freeze his bike engines to stabilize the dimensions of the forged-aluminum pistons. Now he runs them at much closer tolerances than the manufacturer specifies. The pistons do not seize.

The standard procedure for promoting dimensional stability, though, is to cycle the metal repeatedly from hot to cold. For some applications the floor temperature is more moderate, but for others, specifications call for a chill to -320 degrees—or even lower. Aluminum and beryllium for aerospace uses are often thermally cycled. Applied Cryogenics treats aluminum that is used to make mirrors for space



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and weaponry. (The company cycles it down to -411 degrees F using liquid neon.) "With aluminum alloys, phase transformations, resulting in the precipitation of elements or compounds, can take place," Christ noted, which could be one reason aluminum is stabilized after treatment.

Stress relief probably plays a part as well. "The more stresses in a material, the more it will distort when you remove some from the surface," Levine explained. "After the freezing, no distortions occur when the mirror is ground and polished, indicating that you end up with a very relaxed metal after freezing."

Frozen notes

In some cases at least, you also end up with a more ductile metal after freezing, Levine maintains.

On my office shelf is a half-finished silver flute he sent to me. The flute maker was having trouble drawing the silver into the stubby "chimneys" for the tone holes. So he formed some chimneys, had the flute frozen, then formed some more.

The difference is dramatic. Most of the "before" chimneys have small fractures around their rims that tend to run about halfway down. Many of the "after" chimneys have no cracks at all, and the cracks that did appear are significantly smaller.

"I think that's incredible," said Levine. "Everybody 'knows' you increase a metal's brittleness by chilling it, but here the chilling made it more ductile." Levine is convinced that stress relief accounts for that.

What about golf balls—and panty hose?

"Plastics are not amorphous substances," he pointed out. "They are long-chain molecules that have some order to them. It is likely we are inducing some kind of transformation in the arrangement of molecules by refrigeration."

The proof? "There are mostly unanswered questions," Levine acknowledged, "and for years no one has even posed them." Marschall hopes to find some answers, but first he must garner enough sponsors to launch his study.

The importance may be more than academic. A recent analysis by the Massachusetts Institute of Technology (Cambridge, Mass.) concluded that six percent of the gross national product is lost to wear. "Think what it would mean if we could reduce that to three percent," said Levine, his voice rising. "We could revitalize the flagging industrial economy of the United States!" He meant it as hyperbole, but maybe he has a point. **PS**

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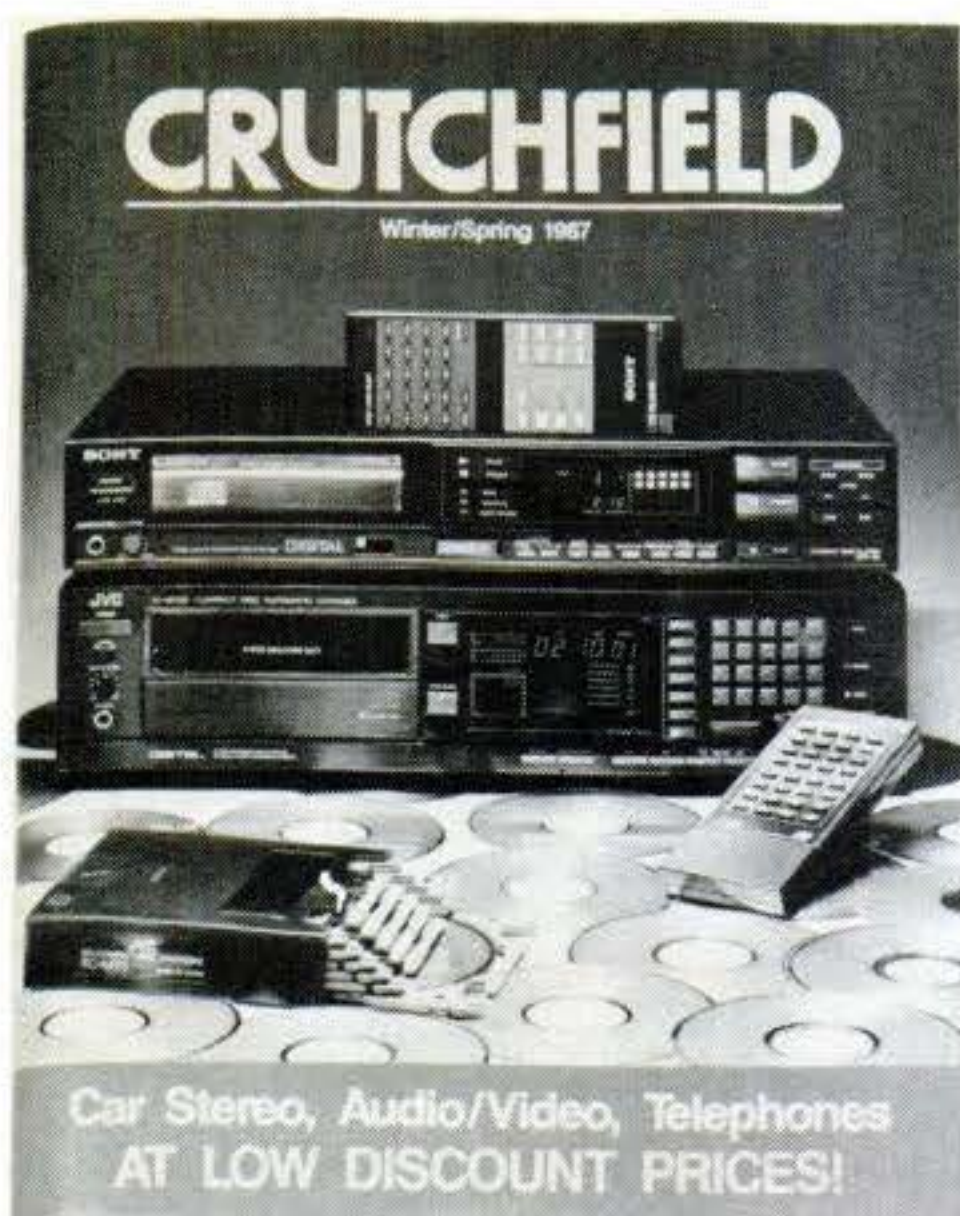
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answered. We knew the energy domain we would have to leap to if we were to escape the limits of this model in its explanation of the fundamental physical entities—if indeed there are such things—and the forces that govern them.”

Supercooled magnets

In 1978, Tigner continued, there was an international meeting of physicists at Fermilab, and the next year in Geneva, at which a number of possibilities for the distant future were discussed, among them a 40-TeV proton collider. “At that time,” Tigner said, “we knew that we would have to use superconducting-magnet technology to achieve the desired energy.”

A superconducting magnet is one whose coils are wound with a superconductor—a material that loses all resistance to the flow of electric current when cooled sufficiently, generally to temperatures close to absolute zero. The magnets used in all accelerators but one use ordinary copper windings, whose resistance generates great quantities of heat, which must be conducted away by water. They also consume gigantic amounts of electrical power. Fermilab’s 400-GeV machine incurred \$14 million in electricity costs in just 26 weeks in 1982.

Even more crucial, the field strength of the magnets—and thus the energy level of the accelerator—is limited in conventional magnets to about two Tesla. In superconducting magnets using the best superconductor (for this purpose) available—niobium-titanium—the field has an upper limit of 15 Tesla. The worth of such supermagnets has been abundantly proved since 1983 in the main ring of Fermilab’s Tevatron—the world’s only accelerator using superconducting magnets. The Tevatron uses 150,000 pounds of niobium-titanium.

The SSC, with its 10,000 magnets, will use much more of this material, which was once considered fairly exotic. I asked Tigner whether any of the newly discovered, even more exotic high-temperature superconductors now causing a great stir (see “Science Newsfront,” this issue) might have any influence on the final design and cost of the SSC.

“We’re following this development with great interest,” Tigner said. “If it should turn out to be useful, we would adopt it so fast you’d think we invented it. But that seems very iffy, mainly because there is no evidence now that these materials could carry a sufficiently great current density in the presence of high magnetic fields. The currents carried are a hundred to a thousand times smaller than in

present superconductors such as niobium-titanium.

“Furthermore, these materials are ceramics. We’d have to find ways to form them into the very fine filaments necessary in a superconducting magnet. And there are other technical problems.

“But suppose your fairy godmother handed you this stuff today with all the problems resolved. What kind of impact would it have on the SSC? Probably not much. Being able to operate at a somewhat higher temperature, say thirty degrees Kelvin instead of four degrees Kelvin, would just not save that much in refrigeration cost.”

Finding a home

In 1983, with the necessary superconducting-magnet technology successfully demonstrated, an SSC group was invited to headquarter at Lawrence Berkeley Laboratory. “Before that,” Tigner said, “it had been almost like organizing a pickup softball game—pretty spontaneous.” As a result of a study conducted in 1984, the DOE gave a contract to the Universities Research Association, a consortium of 56 research universities, to carry out a detailed design-and-cost study and form a special organization to do the job—the Central Design Group. “We’ll probably stay at Berkeley,” Tigner said, “until we move on-site in 1989.”

Finally, I asked him about the criticisms of some scientists that the SSC will divert money and talent away from equally or more important research. One such critic is the radio astronomer and physicist, Arno Penzias, a Nobel laureate. “The Super Collider’s capital cost,” he has written, “will clearly squeeze capital expenditures for other sciences.”

Here is Tigner’s response: “None of us for one moment would want to press on with this great wave of discovery in particle physics if it were to come out of the hides of other scientists. We may be parochial in certain respects, but we have a deep respect for science as an entity; to make a huge advance in one part of it at the expense of others would be a bad mistake. We are very happy to see that the SSC is viewed in the administration as going forward in the context of a big increase in the other sciences—for example, the National Science Foundation budget is targeted for doubling in the next five years. We are very anxious that other scientific areas that are ripe for progress should be supported.

“If our country and culture fail to make such investments, then we are doomed to decay.”

PS

Techno-tractors

[Continued from page 87]

Plowing the rocky ground was easy with 4WD, and the RT5000's 11-hp 340-cc gasoline engine hardly strained. At the end of the furrow, I got a good feel for the tractor's 4WS. As I turned the steering wheel, the front tires angled as expected but the rear tires crabbed slightly in the same direction. As I continued to rotate the wheel, the rear tires turned in the *opposite* direction from the front (see photo). Result: a tight, quick turnabout.

Why bother with 4WS? According to Chuck Lebo, assistant manager of field service operations at Honda, "One of the prime reasons for four-wheel steering is that we can get a much-tighter-than-normal turning radius out of a decent-size tractor—without scuffing turf with the rear tires. And obviously, with four-wheel drive that scuffing would be compounded if we couldn't turn it effectively."

The all-mechanical 4WS in Honda's \$4,980 tractor resembles the company's automotive system, except it has one steering box instead of two. Kubota, on the other hand, uses electronically controlled hydraulics.

Kubota considers its large PX-2100 tractor a technology test bed. Instead of a steering wheel, the driver uses a double-handled yoke with bicycle grips. The tractor can be operated conventionally, or it can be controlled through a remote-control unit. The only functions that can't be controlled remotely: engine and throttle.

Even more unusual, three steering modes can be selected: front-wheel steering (turning radius: 9.5 feet), 4WS (front and rear wheels turn in opposite directions for 6.2-foot radius), or crab steering (all wheels turn in the same direction). All steering is micro-processor-controlled through potentiometers and hydraulic valve gates.

In fact, all of the tractor's operations are monitored by an on-board computer reading data from a variety of sensors. If oil pressure drops or the water-cooled 20-hp diesel engine overheats, for example, the computer shuts the tractor down. And interference from another transmitter also will trigger a shutdown.

I ran the PX-2100 back and forth across Kubota Tractor Corp.'s lawn in Compton, Calif., using the remote controller. The tractor reacted quickly and precisely to every command. With a few minutes' practice, I was able to have the machine do exactly what I wanted it to do. The transmitter's range is about 300 feet.

Retail price for the PX-2100 is about \$22,000. Kubota expects to sell it for such professional mowing applications as highway medians, steeply sloped public lands, and parks.



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tion. Door assemblies, for example, can be tested separately from the car on which they end up by plugging automatic testing equipment into the multiplexing link before the door reaches the assembly line. Another goal is simplifying diagnostics: With all of the car's computers on a single communications link, a diagnostic computer can easily tap into the circuit and read the health of each component on the line.

But the current generation of multiplexing is only the beginning. "On the

horizon are electronically controlled transmissions, electrically assisted steering, electronic throttle control, and even active suspension systems," says Chrysler electronics engineer Dennis E. Florence. "Alone, these systems are complex. To maintain quality levels at reasonable cost, they will have to be integrated into the vehicle rather than remain independent.

"Moreover," adds Florence, "as wiring systems continue to get more complex, multiplexing is rapidly becoming mandatory."

One piece of technology anxiously awaited is a so-called "smart motor" that incorporates enough computer intelligence to respond directly to information on a multiplexed network. Such a motor would be part of a so-called "fly-by-wire" approach to a system like steering, where computer commands directly control mechanical power.

High-speed multiplexing also means new communications systems would have to be developed. The single or twisted-pair wiring currently in vogue acts something like a radio antenna at high transmission speeds, scrambling on-board computers with unwanted radio interference. For this reason, fiber optics is being considered by auto makers, and a fiber-optic seat control has already been tried by Nissan Motor Co., although current fiber-optic technology is considered too expensive for routine use on cars.

Overloaded camel?

Envisioning these more-complex technologies brings to mind an overloaded camel brought to its knees by the addition of one last bundle of rugs. The interaction of future high-speed electronics systems within the basic framework of today's mechanical-engineering concepts has already led GM to propose a different approach to car development.

Naming its approach Project Trilby, GM has set up a combined engineering group staffed by both traditional auto engineers and new recruits from Hughes Aircraft Co., now a GM subsidiary. Project Trilby is an effort at designing a car from the point of view of an electronic system, or as one description puts it: "What if we had computers before we designed the first car? What would we do then?"

Though the specifics of Project Trilby have not been discussed publicly, bits and pieces have emerged. The steering wheel on a new Pontiac show car, for example, does without the traditional steering shaft, one of the principal safety hazards to the driver in a front-end collision. Instead, it uses a two-handle bar that is connected to a simple rheostat. On-board computers deduce steering input and send signals to electric steering controls at both front and rear wheels.

A "Trilby question": If there is no need to worry about a steering shaft, is an angled wheel in front of the driver the best steering device? Or by extension: If the driver's controls can be easily located anywhere, where should they be?

Smart power, it seems, is already asking more questions than it is able to answer.

Scientific Study Ranks NordicTrack #1

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2. An Exercise Bike
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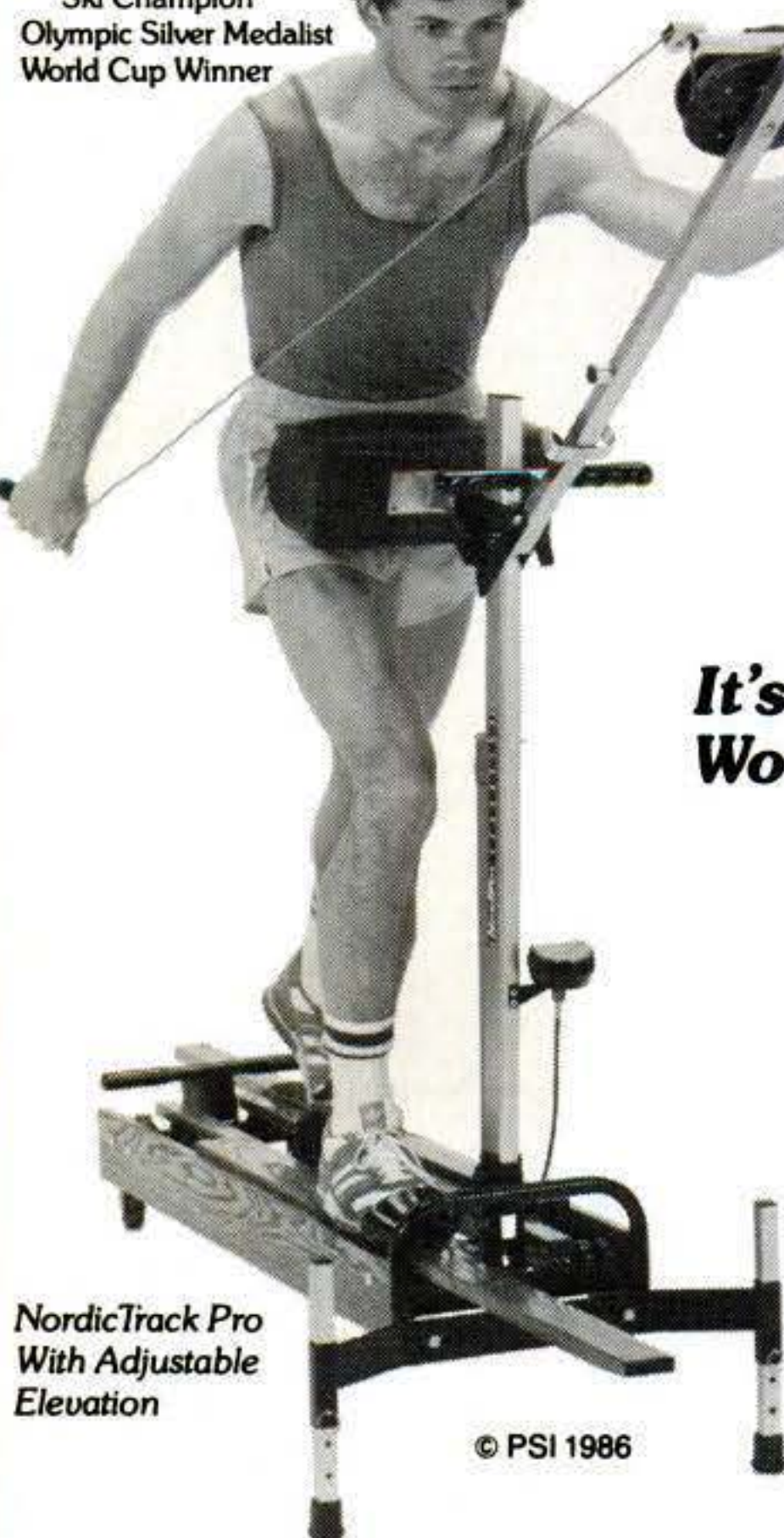
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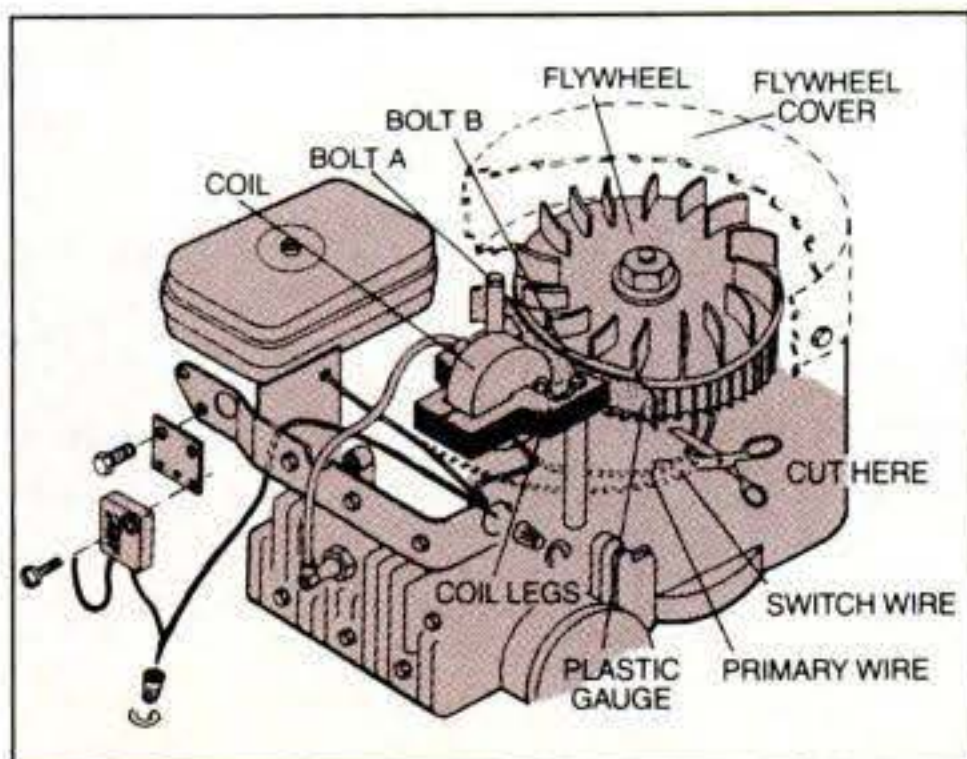
Microchip ignition for yard machines



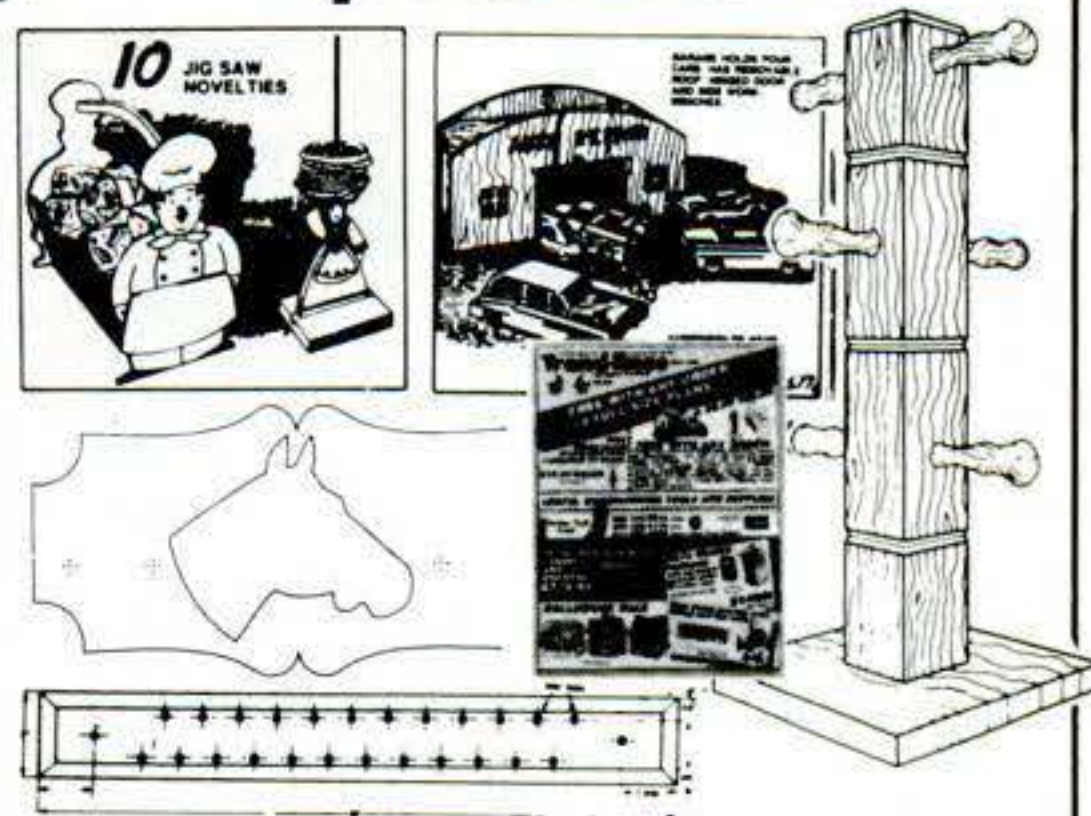
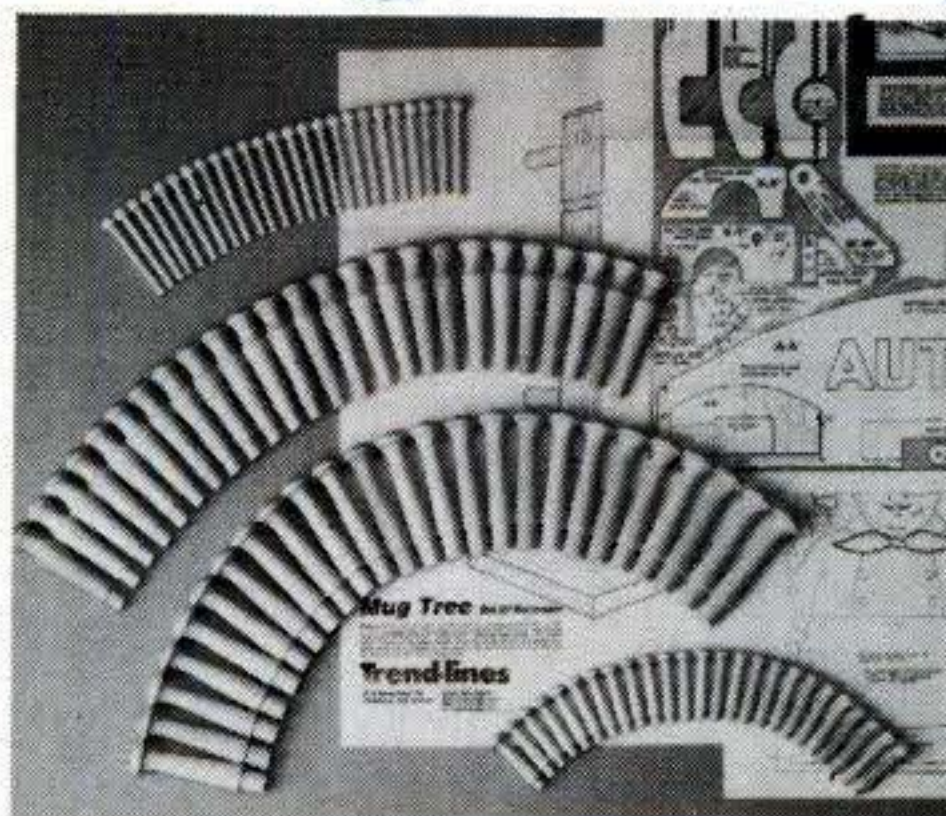
It used to be easy. I'd reach down and pull the rope, and my lawn mower would roar to life. But that roar recently became a snarl: Despite a new plug and oil change, my faithful lawn companion needed lots of coaxing to get started. The problem: A worn and pitted breaker-point ignition. The solution: A microchip ignition system—which is about the size of a postage stamp (see photo above)—that electronically replaces the points and capacitor.

Made by Power Lawnmower Parts (Box 60860, Rochester, N.Y. 14606-0860), the tiny Power-Start module installs in about 30 minutes. To do it, you cut the coil's primary and switch wires, and connect them to one of the module's leads (see drawing below). Once the job was done, I pulled the rope once again and checked the ignition. I saw the fattest, bluest spark I'd ever seen from that engine.

The Power-Start works on all small engines—from lawn mowers to chain saws—but it's not recommended for engines already equipped with an electronic ignition. Prices are from \$13 to \$15, depending on the engine model. —E. F. Lindsley



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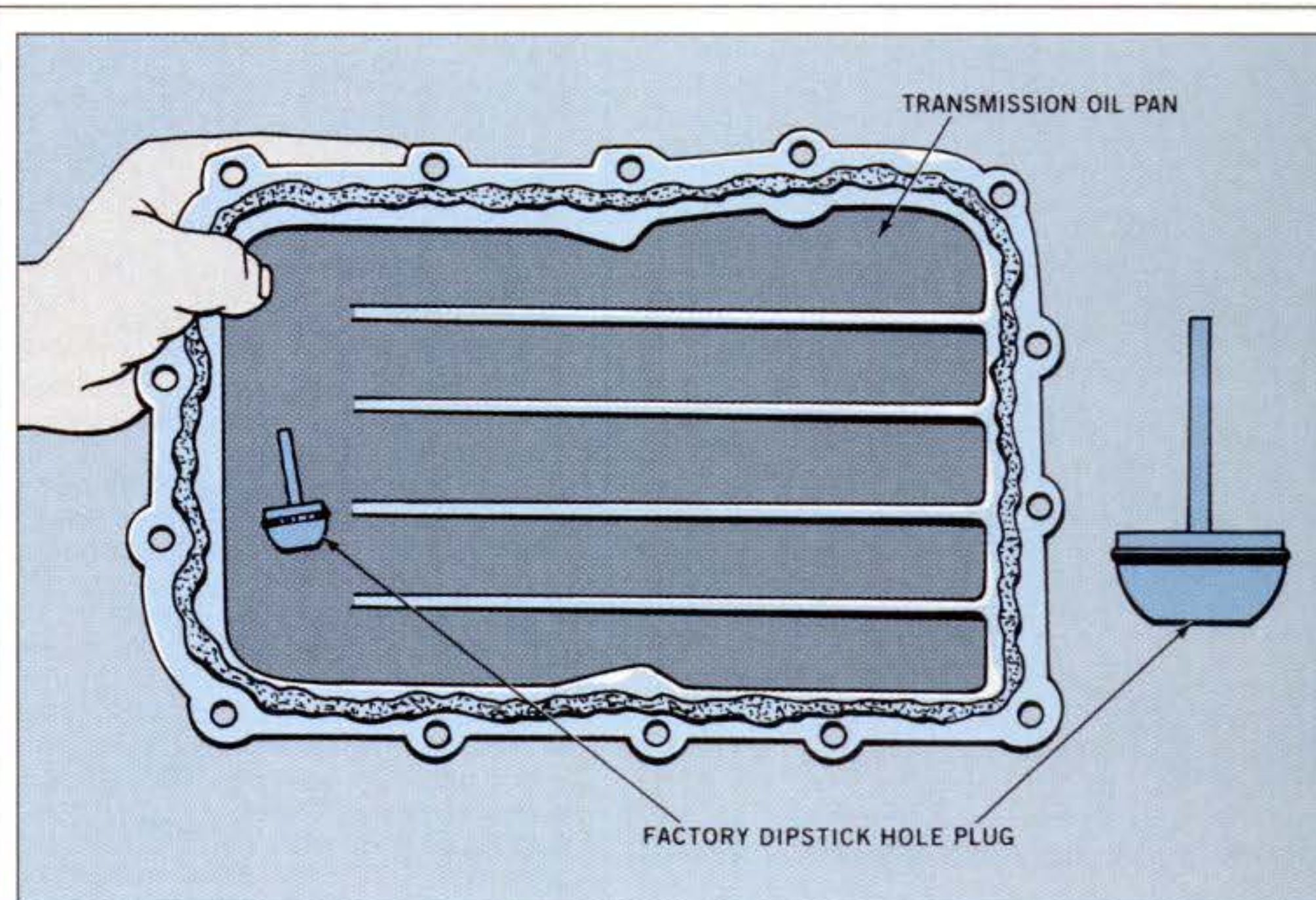
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Taking Care of Your Car

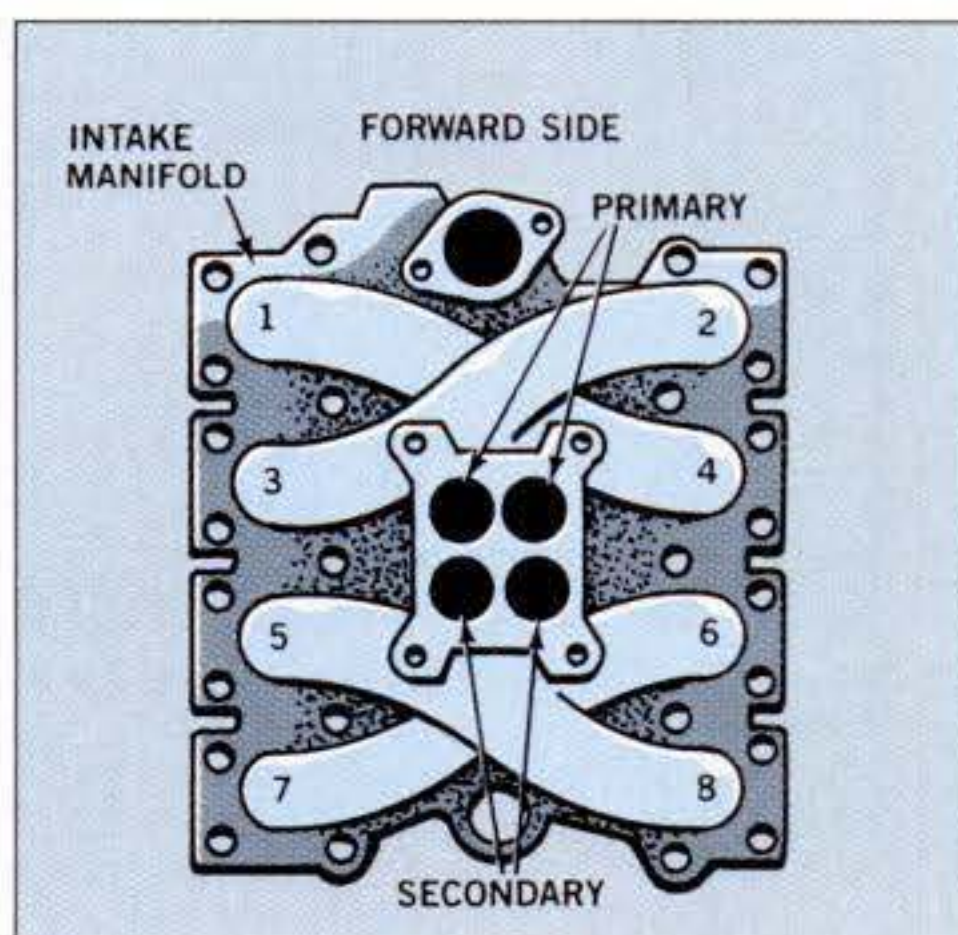
By STEVE MERCALDO



Mystery plug

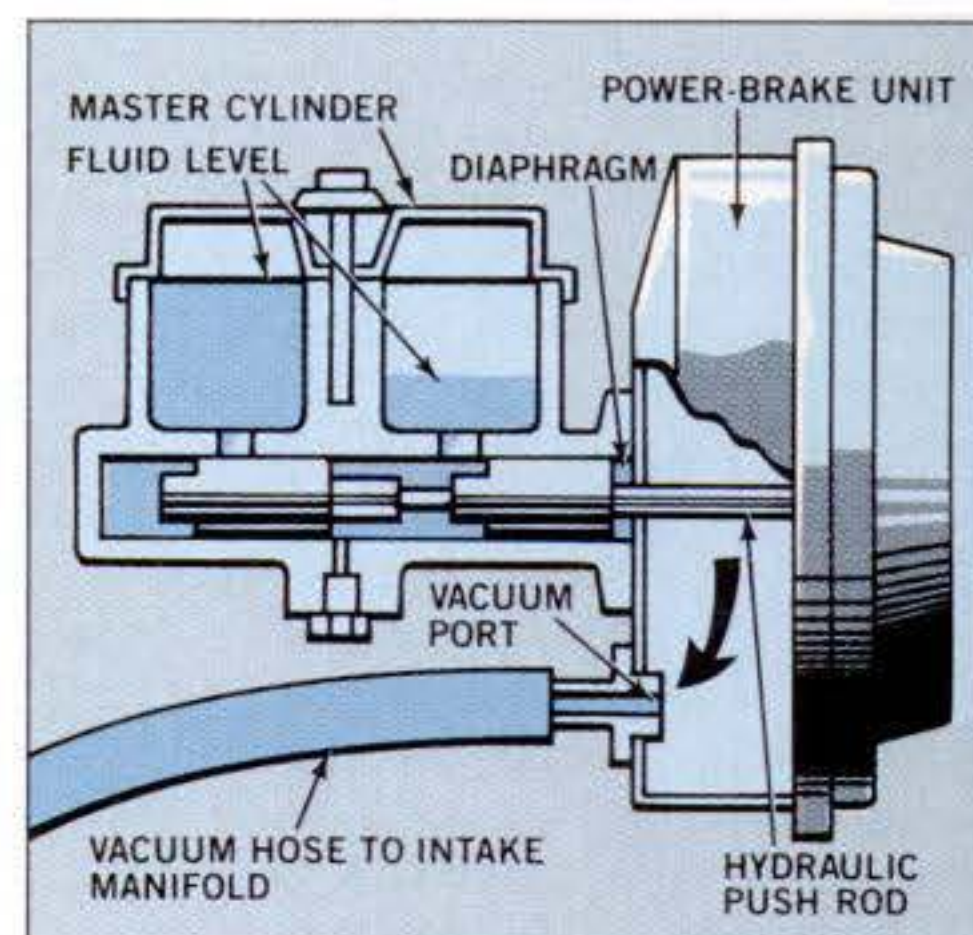
If you're a careful car owner, you may eventually find yourself changing automatic transmission fluid (ATF). During an ATF change, some conscientious mechanics have been puzzled—and possibly upset—by a small important-looking component lying loose in the bottom of the transmission pan. But

if you find one of these man-made mushrooms with an O-ring, don't be concerned. It's simply a safety plug used to keep foreign matter out of the transmission during manufacture. During the installation of the dipstick tube, the plug is simply pushed down into the transmission body.



Carburetor clues

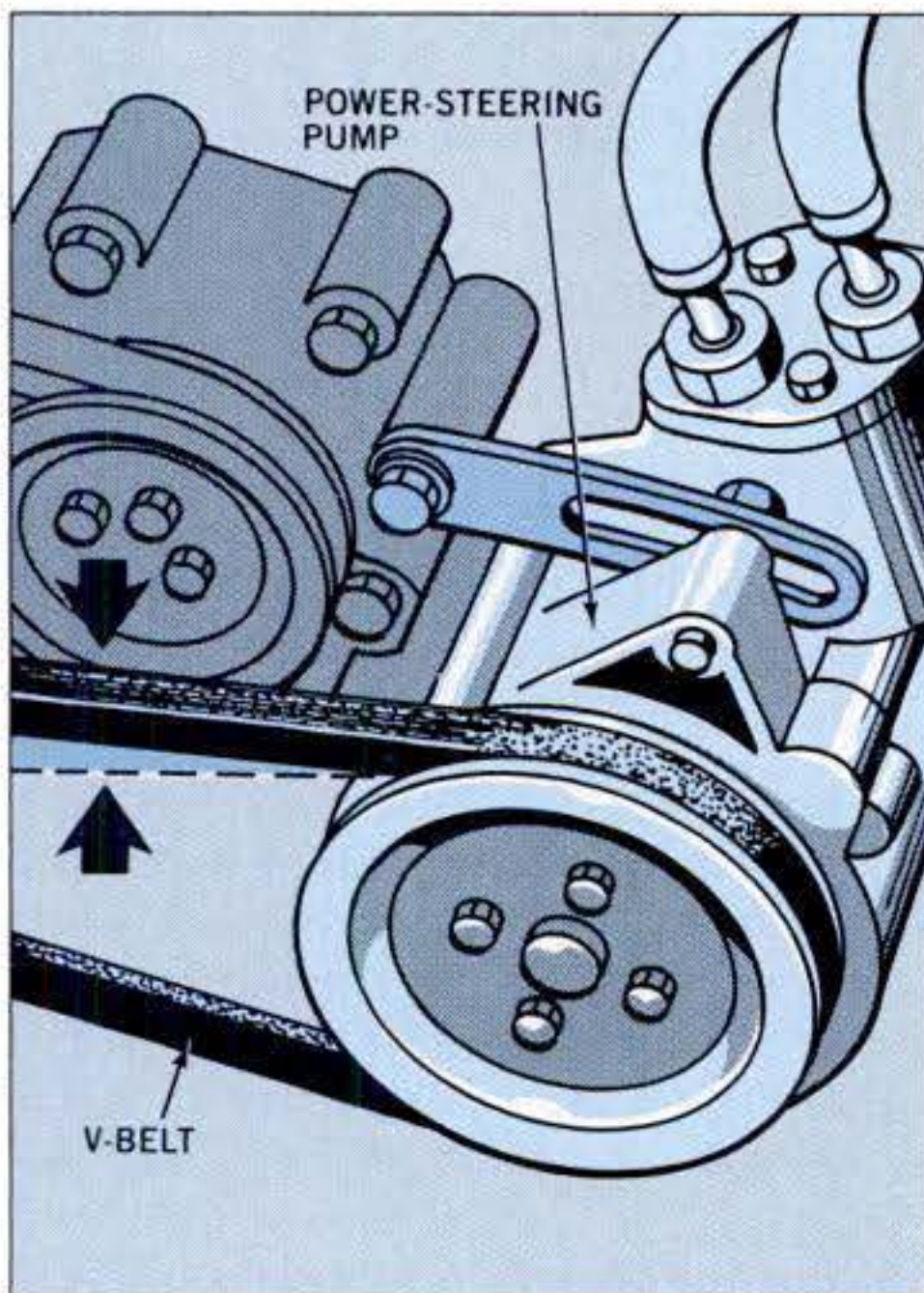
Most V8 intake manifolds are designed so that opposite bores in the carburetor feed alternate cylinders in the firing order. For example, when the firing order is 1-8-4-3-6-5-7-2, the left bore feeds cylinders 1-7-4-6; the right bore feeds 8-3-5-2. This information can be handy when you're troubleshooting carburetor gremlins.



Disappearing brake fluid

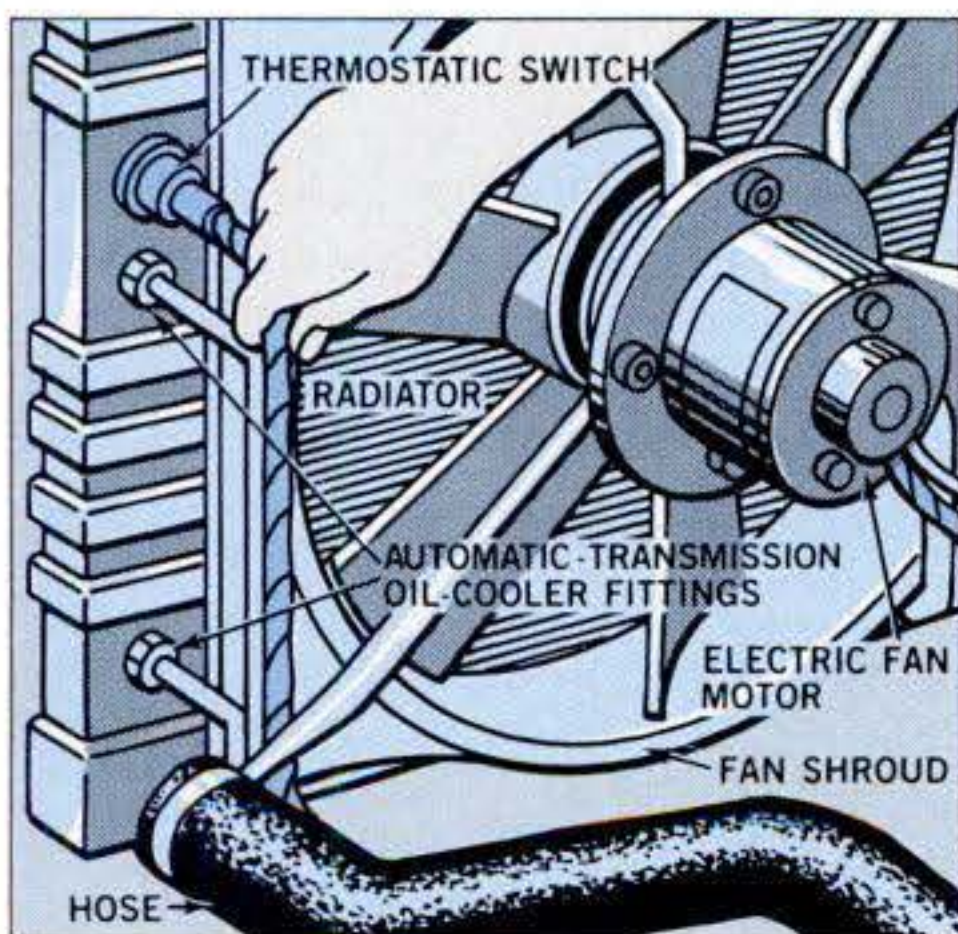
Is brake fluid vanishing from your car's master-cylinder reservoir but you have no leaks in the car or traces on the driveway? Are gray-white clouds of smoke spewing out of the tailpipe during hard stops or sharp turns? A master-cylinder seal has probably given up and is allowing fluid to be sucked into the engine and burned.

Got a useful car tip? Send it (with Social Security No.) to Car Care, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. We'll pay \$50 if we use it. No tips can be returned.



Steering stutter

If your vehicle's power steering stutters (alternately losing and gaining power) as you negotiate a turn, check for a loose or worn V-belt. The erratic performance of the steering is caused by the intermittent loss and resumption of hydraulic assistance from the system's belt-driven pump.



Fan fare

If an engine is obviously overheating and the electric radiator fan is not spinning, check the connection at the radiator's thermostatic fan switch. If the fan operates when you jiggle the connector, the connector or switch terminals are loose or corroded. After the engine has cooled down sufficiently, make the simple repair.



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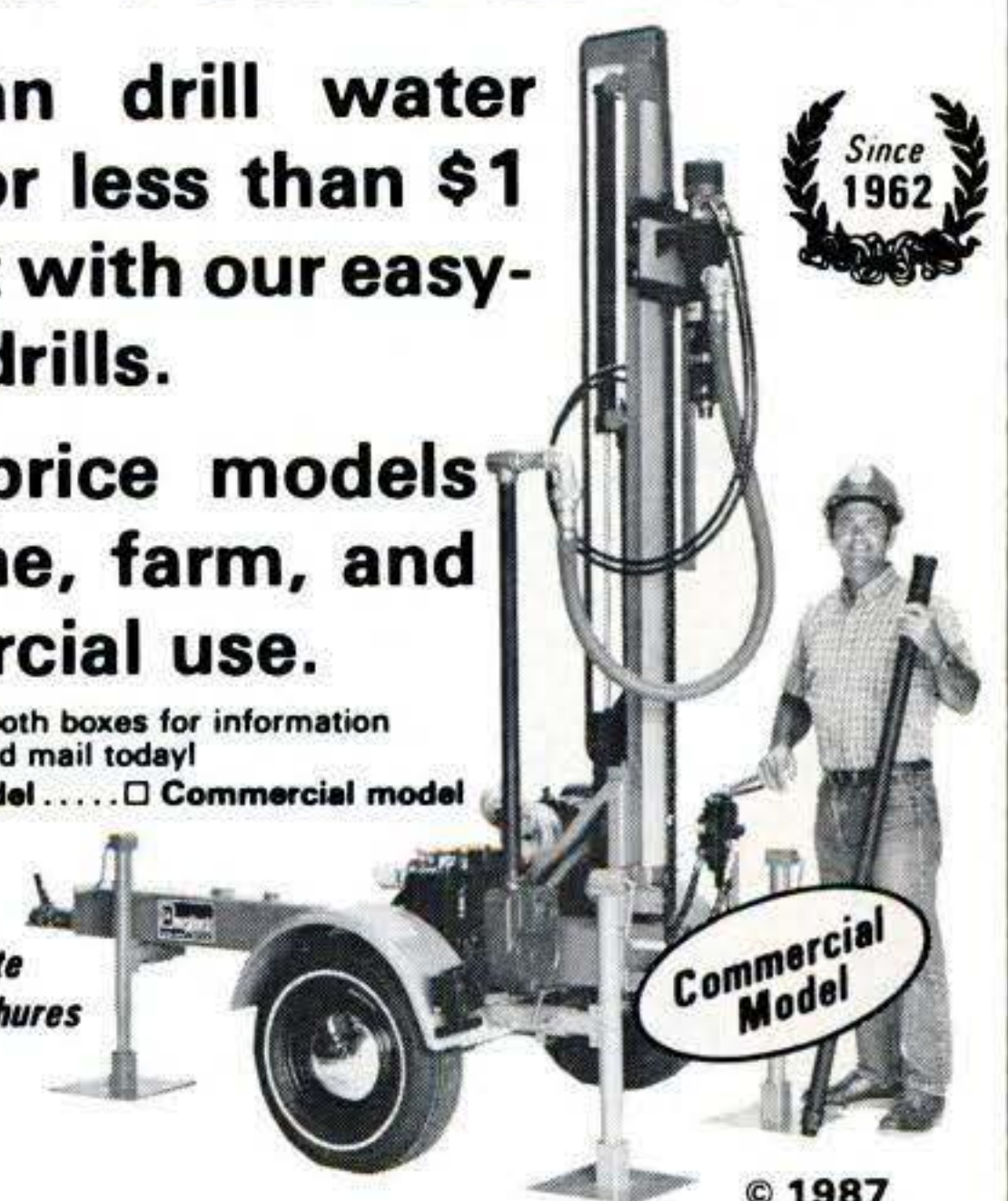
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Pro tips for repairing exterior masonry



Cracks in concrete and mortar require preparation before patching. But concrete won't stick to concrete. You need the right repair materials to make the fix a lasting one.

Masonry repairs aren't usually the first projects that come to mind when homeowners contemplate working on their houses; available cash is more likely to be invested in interior decorating and remodeling. But the stresses of successive winters leave many homes with unsightly cracks in foundations, steps, and driveways that only get worse—and far more expensive to fix—when left unrepaired.

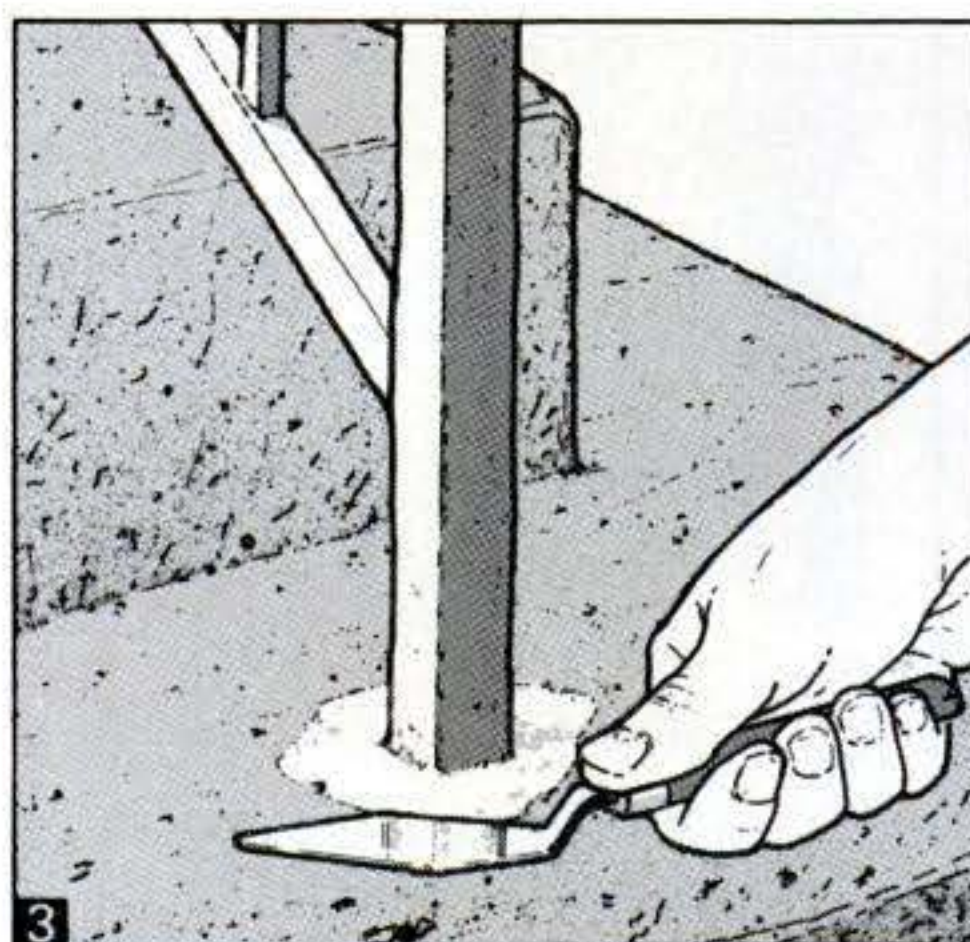
Cracked masonry should be repaired promptly, especially in regions where winters are severe. Even a small crack allows moisture to penetrate the concrete, where subsequent cycles of freezing and thawing soon cause further deterioration.

The effective cure for cracked masonry, however, isn't the obvious one. "Slapping concrete into a hole won't solve your problem," warns Murray Steinberg, research chemist at Red Devil in Union, N.J. "Concrete surfaces can't be repaired with concrete because the coarse gravel elements in the new mix prevent bonding between the patch and the damaged area."

Cracks in concrete or cinder-block foundations, Steinberg advises, should be quickly repaired with a commercial patching material that is specially formulated to form a strong bond with concrete. Fine cracks in steps, driveways, or garage floors can be filled with cartridge-packaged, ready-mixed repair material that is dispensed from a standard caulking gun. If rock salt and ice have loosened the foundations of wrought-iron railings, anchor cement is available that sets rock hard in just 15 minutes.—*Stuart F. Brown*



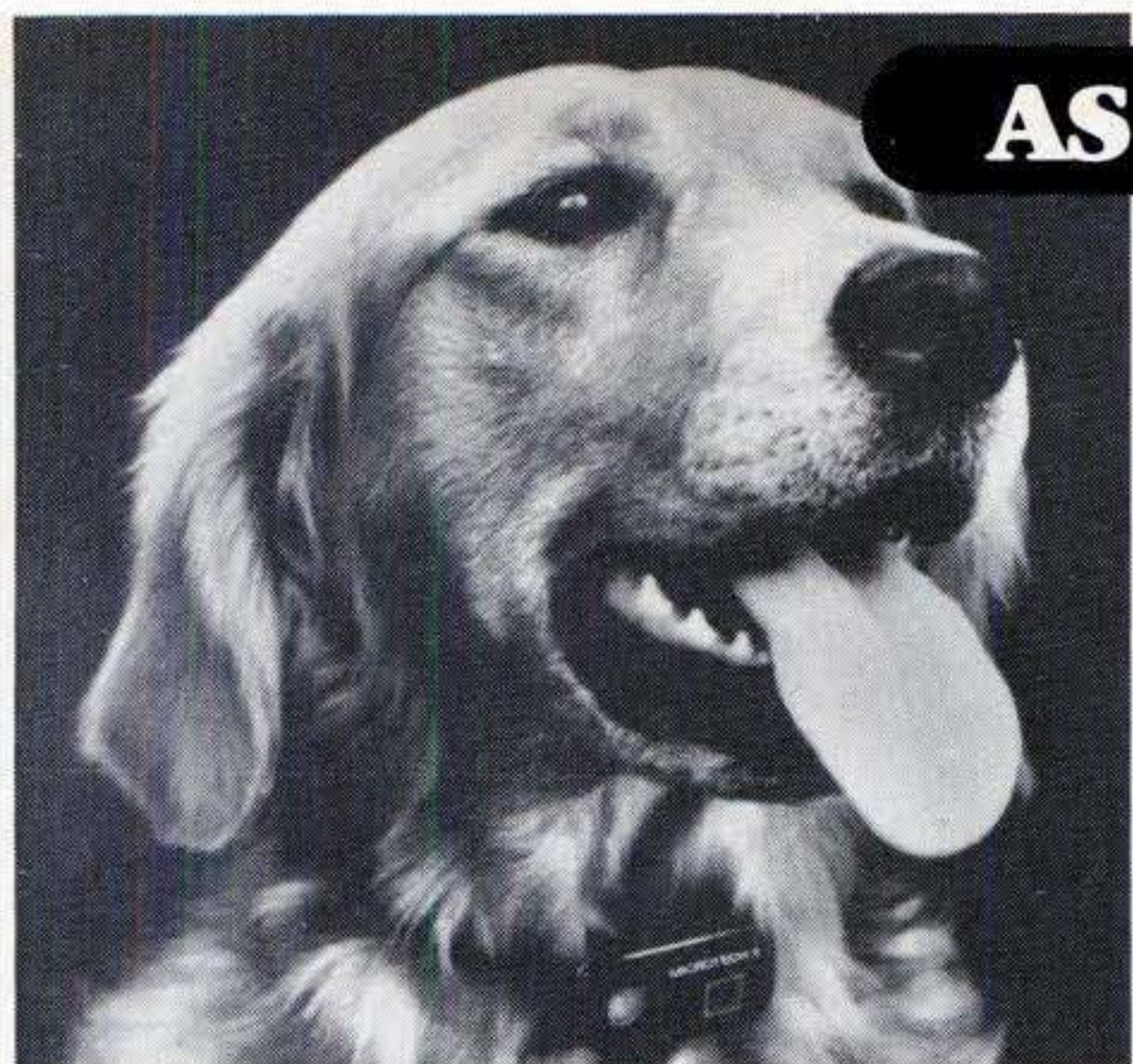
Clean vertical cracks in concrete or cinder-block foundations (1) with cold chisel and brush to remove loose material. Moisten exposed area, then cover lowest segment with strip of ducting tape and tape a funnel at the top. Prepare thin mix of patching material in



bucket and pour into crack. Don't try to repair more than three ft. of crack at one time. Remove tape when patch sets (inset). Use putty knife or old screwdriver to scrape loose fragments out from between fieldstones or bricks (2). Fine cracks up to 1/8 in. wide can

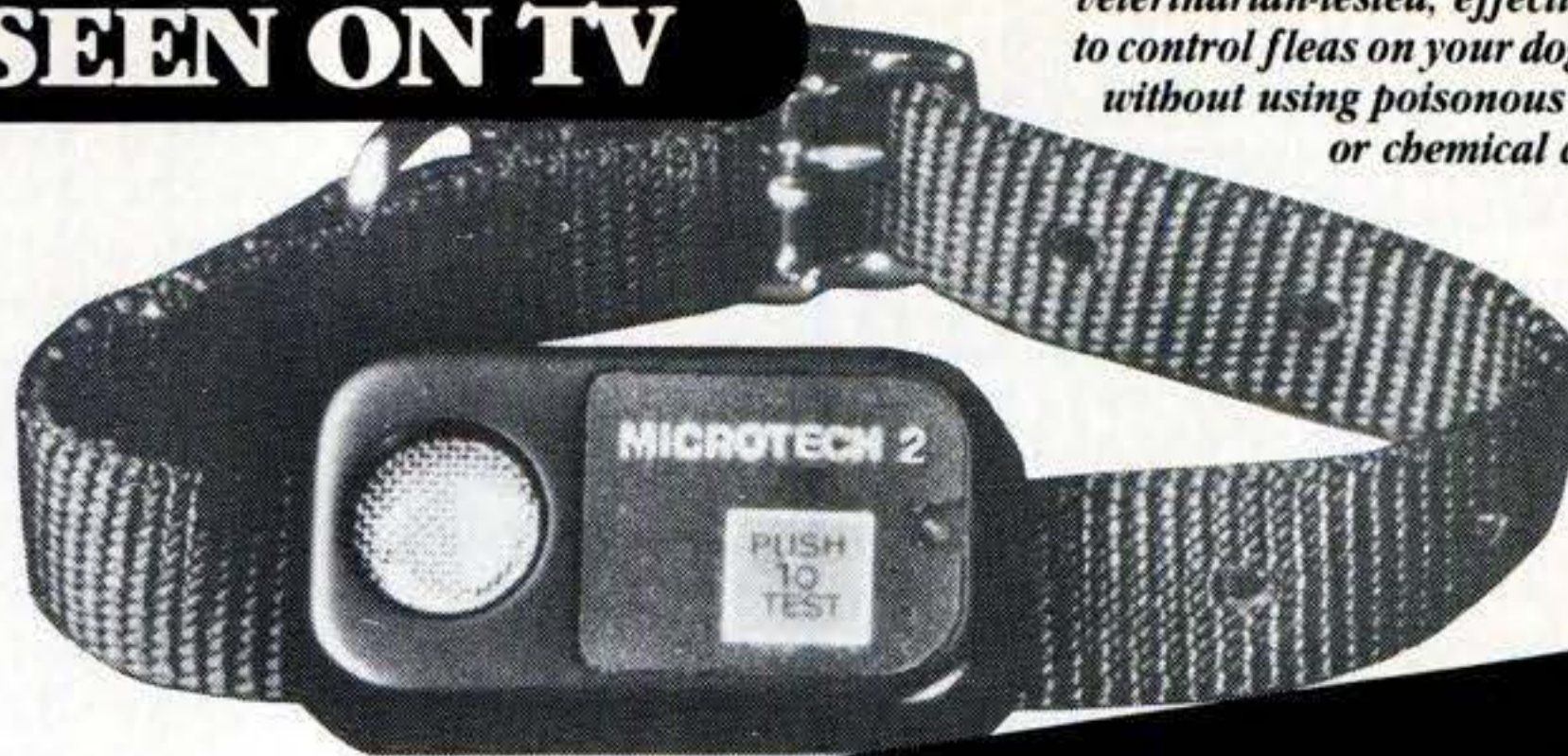


be filled with ready-mixed concrete and mortar repair material from cartridge gun. Putty knife removes debris around iron railing (3); use it to apply anchor cement, too. After applying a patch, smooth with sponge (4). When it has set, smooth further with coarse abrasive.

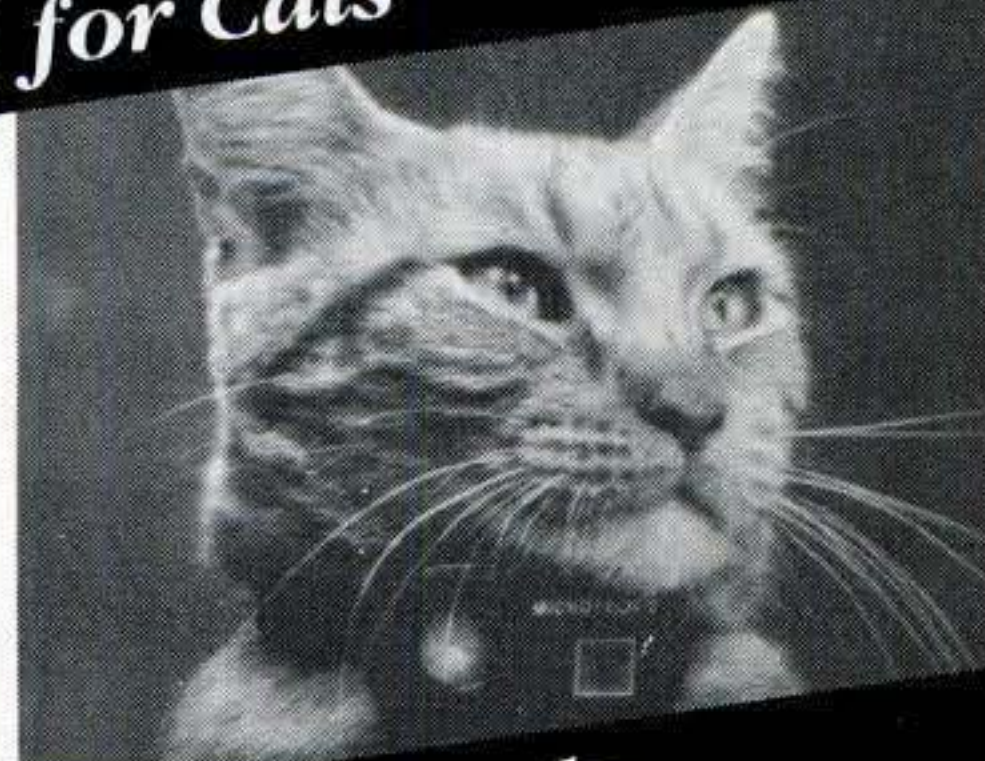


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— G.R., Key West, FL

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Molecular memory [Continued from page 63]

ories to shame, storing 1,000 gigabytes of data, or the equivalent of two million disks, in an area the size of a single diskette. Although conventional laser-disc optical recording provides a hundredfold improvement over magnetic storage capacities [May '85], this capacity is finite, limited by the approximately one-micron size of a laser spot, which normally holds one bit of data. (In computer storage, one byte generally contains eight bits.)

This spot size has been decreased experimentally by one-fourth ["Electronics Newsfront," Oct. '86], but IBM's new storage technology could store 1,000 bits in the one-micron spot. Researchers are achieving this by tapping the storage capability of individual molecules within that laser spot. It is a technology that requires exotic materials and supercold temperatures. But its implications for data storage are staggering. Here's how it works.

Imperfect crystals

If you had an absolutely perfect crystal and filled it with absorbers of light (molecules, ions, atoms) at temperatures approaching absolute zero, they would all absorb light at an identical wavelength. The wavelength that a molecule absorbs depends on the frequency at which it is resonating when light hits it, which, in turn, is determined by the molecule's surroundings. In a perfect crystal, those surroundings are identical for every molecule, and they all resonate at the same frequency. But, according to Macfarlane, "In a real crystal or polymer, some local environments are different from others. When you grow a crystal, you lock in a certain amount of disorder, meaning strains and dislocations in the crystal lattice." The result: When the crystal is at liquid-helium temperature, the molecules resonate slightly differently and absorb light at slightly different wavelengths. The range of the absorption covers a continuous frequency spectrum (see first drawing).

This range of laser frequency absorption at a given spot is the key to the IBM research: It is the basis for recording the digital 1s and 0s computers use to store information. The researchers use materials whose molecules can be changed, or "bleached," when they absorb their signature light frequencies. This bleaching, which represents a digital 1, is actually a chemical reaction and changes the molecules' characteristic absorption. This leaves a dip, or spectral hole, in the absorption spectrum (drawings).

Macfarlane and co-researcher W. E. Moerner made these bleachable materials themselves. "We found that we could actually measure where a spec-

tral hole had been made by scanning a laser across all the intermediary wavelengths," says Macfarlane. "When we got to a wavelength where a hole had been made, the absorption was much smaller." But there was a major snag in the scheme. The laser used to burn a spectral hole, or 1, was the same one used to read, albeit at much lower intensity. "If you use the same laser for writing and reading, when you read you end up smearing out some holes," says Moerner. "What we had was destructive reading."

Threshold burning

The solution to the problem took several years to develop. "We decided to try to find materials that needed a combination of two lasers to bleach molecules but only one to read," says Moerner. This makes writing a threshold process—a two-step photoreaction involving two different colored light sources. One is finely tuned and selective, and the other a nonselective shot of energy. "These materials have only existed about a year and a half," says Moerner. "We now have about half a dozen of them, some of which are organic polymers." They are called photon-gated materials—the photon refers to the extra light source, and the gate is open for bleaching only when the second laser is on.

One of the successful photon-gated materials consists of electron-rich samarium ions scattered in a barium-fluorochloride medium. Moerner explains the process: "Before you burn anything there's a distribution of samarium ions that absorb at a certain red color. The ions have a lot of electrons buzzing around them, and using a narrow-band red laser you can select out these ions. A green laser just acts as the gate, providing enough energy to whip an electron away. What that does is shift all the frequencies where this molecule can resonate, and its character is changed completely." Moerner says that in this particular material the bleaching technique is a photoionization process: The samarium ion loses an electron, which is whisked away to a trap (an electron-hungry molecule) elsewhere in the material. At low temperatures, the electron can't go back to the ion.

"But if you go back with a third laser light—in this case blue—you can empty that trap and put the electron back again. That's what makes this process reversible," says Moerner. The returned electron restores absorption at the original frequency.

The fundamental limits of this system are very far out. "By multiplexing in this frequency domain as well as in the spatial domain [spot to spot],

you make something that's just monstrously big—a thousand gigabytes for example,” predicts Macfarlane.

What would a frequency-domain optical storage system look like? Well, for one, it would not be a disc format because you don't need to rotate the medium. Conventional optical and magnetic systems often have rotating media to get enough material beneath the read and write heads. But ultimately a disc format is limited by the time it takes for the disc to rotate. Macfarlane's vision of the frequency-domain storage system differs radically from existing computer memories: “Imagine there's a big pool of liquid helium, and there are these squares coated with the photon-gated material inside. The read/write laser is actually outside the pool, and there's a movable mirror that bends the laser beam toward a specific spot on a square.” A photodiode detector registers the spectral holes. Data are identified by where they are spatially and what frequency they are at.

There are problems that will probably hinder development of a commercial molecule memory system for at least 10 years. For one, photon-gated materials have not yet been developed that function in the infrared-wavelength range of tiny diode lasers. “There is no fundamental reason why not,” says Macfarlane. “It's just a matter of finding the right materials.” Right now, the researchers use a large tunable liquid-dye laser to simulate the gating effect.

Another problem is that it is often difficult to make a strongly absorbing sample of these gated materials as thin films. But perhaps the biggest problem is the need to operate at liquid-helium temperature. “If you have the material at room temperature, the atoms are shaking around, and that motion limits the selectivity of absorption,” says Macfarlane. The low temperature is also necessary because usually data are lost when the material warms up to room temperature. However, some recently discovered materials can warm up and cool down without losing data.

Moerner and Macfarlane stress that their research is not yet a viable technology. “You can go in and write information and retrieve it, but the technology is not practical yet,” says Moerner. “We have many of the required properties—although not all in one material. We can burn fast—in thirty nanoseconds—make small spots, read with high signal to noise, create thin films from some materials, and operate at a red wavelength.” The final step is to combine these properties into one material. **PS**

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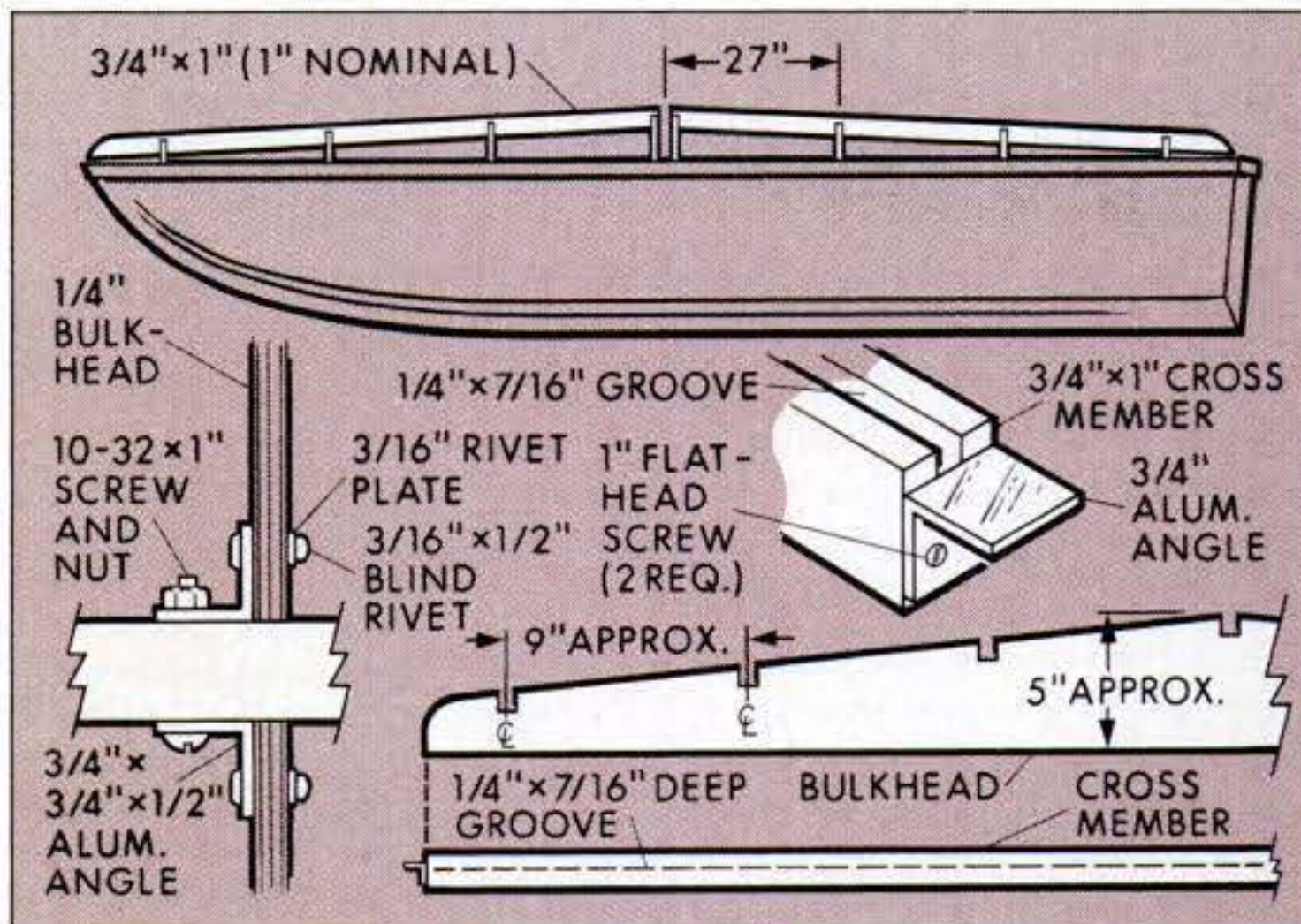
Easy-on, easy-off boat-cover rack

Here's a simple way to keep your boat's fitted tarpaulin puddle-free—an easy-to-build boat-cover rack. The two-piece rack straddles the boat and is both crowned and inclined for runoff. Screw-and-rivet joints make it strong and easy to handle—it just drops into place.

Use 3/4-inch-thick redwood except for the bulkheads, which are 1/4-inch exterior-grade plywood. Cut the cross-pieces to set 27 inches on center. Then rip narrow grooves for the bulkheads so the joint won't need glue. Shape the center bulkheads to give a five-inch crown, and then cut notches in the curved edge, nine inches on center. (Keep the notches 1/4 inch shallower than the redwood strips so the tarpaulin won't sit on the bulkhead edges.) Shape the fore and aft bulkheads to create the incline shown.

Attach 3/4-inch-long sections of aluminum angle extensions at ends of crosspieces, to rest on gunwales. Drop the four bulkheads into place to determine height, and notch locations for intermediate bulkheads by laying redwood strips in place. Finally, assemble the rack on the boat, and fasten the framework.—E. F. Lindsley

Handling fore and aft sections is a one-man job (photo). For joints, use 1/2-in. lengths of aluminum angle. Drill 3/16-in. holes using drill-press vise for 3/16-by-1/2-in. rivets and one-in. 10-32 screws. Hold angle with locking pliers; drill through plywood. Insert and pop first rivet. Drill screw hole, slip on angle, and snug down nut. Attach second rivet as shown.



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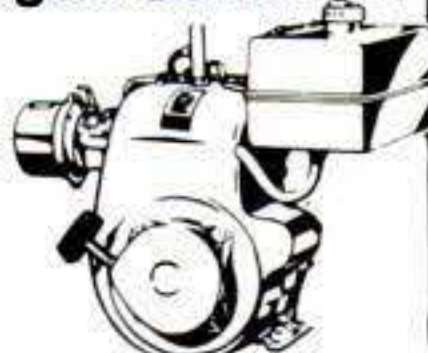
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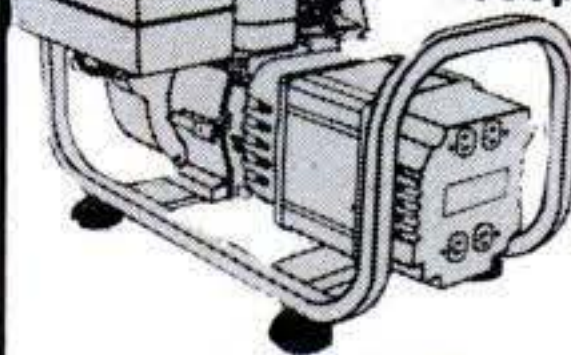
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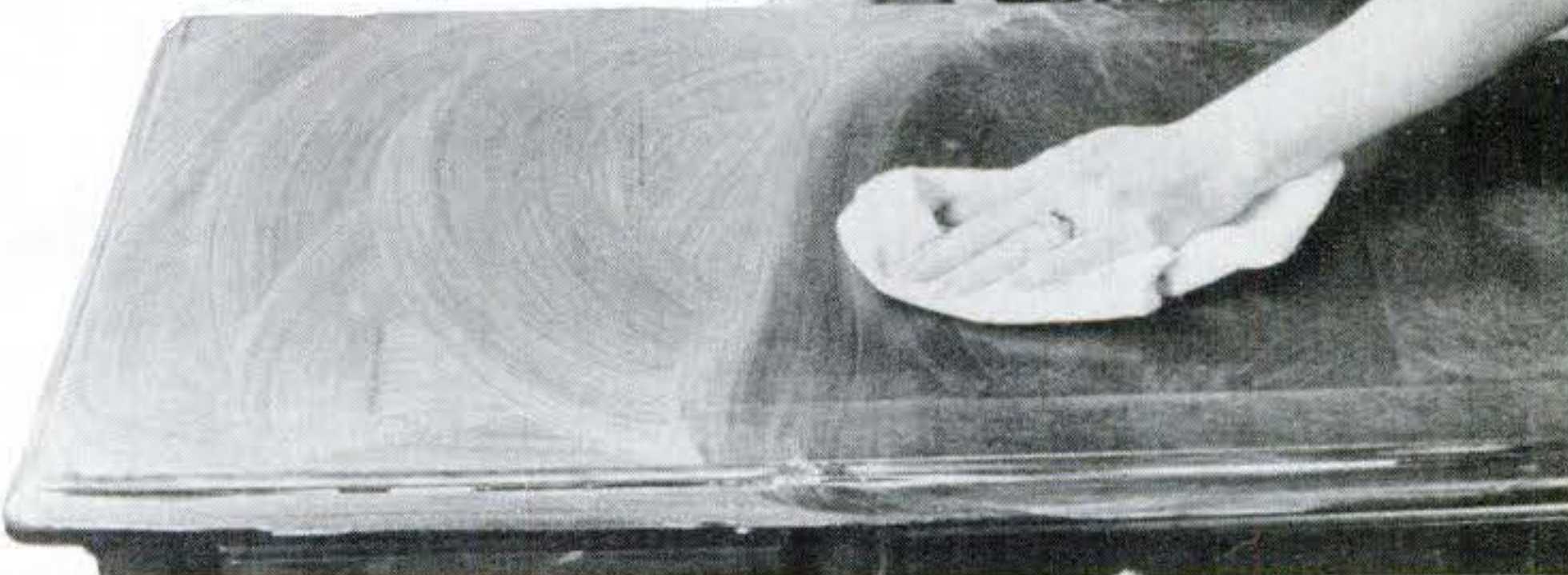
Water spots and other signs of wear and tear ensured that my oak dining table was always kept hidden under a tablecloth. Refinishing seemed a drastic step, so instead I tried Formby's Furniture Face Lift, a different approach to wood treatment. The three-step kit (\$16 to \$18) is designed to *revive* the existing surface, not re-finish it, and can be used without mess in one hour.

Step one: Clean the wood's surface. Following Formby's instructions I squeezed the pearly-pink cleansing liquid onto the table. Rubbing vigorously in a circular motion with the included pad worked up a gray foam as it released the ingrained dirt.

Step two: Apply Formby's buffing cream using the same circular motion. I could see the various marks disappearing beneath the gritty yellow liquid. And this improvement occurred so rapidly that I never needed the recommended two minutes of buffing time.

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the buffing cream must be removed completely, using the remaining cleansing liquid and lots of cotton rags. This is not an easy job because as the liquid, dirt, and cream dry, they form a tough film.

Step three: Let the clean wood dry for 30 minutes, and apply the clear finish. I applied the finish in a circu-

lar motion to one half of the table at a time. Then I carefully smoothed over the same area, going with the grain. Though it takes only minutes to apply the finish, the surface needs at least three hours to dry. If your results are as good as mine, you'll be left with a hard shine that looks like new.—Nancy Negovetich

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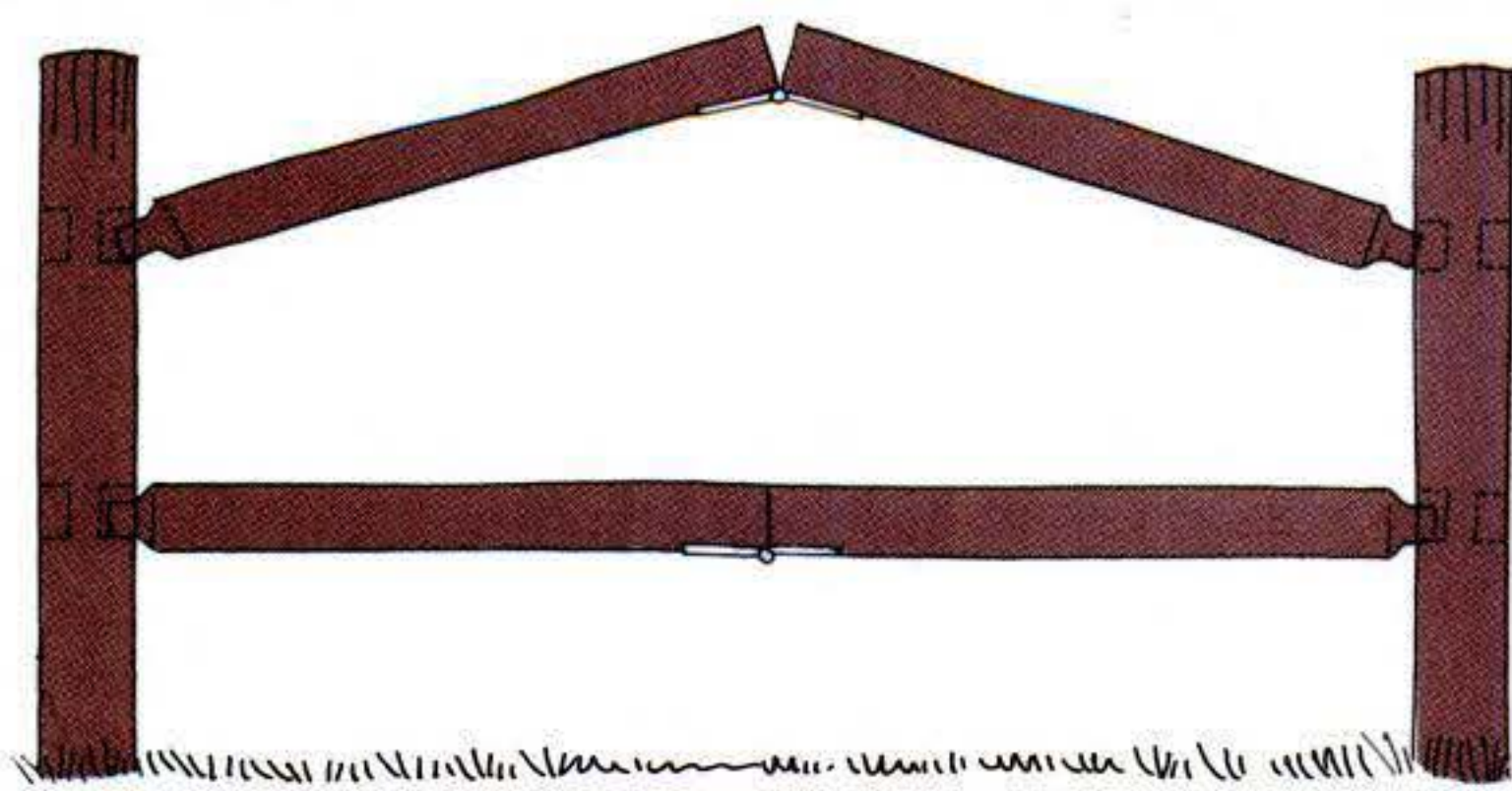
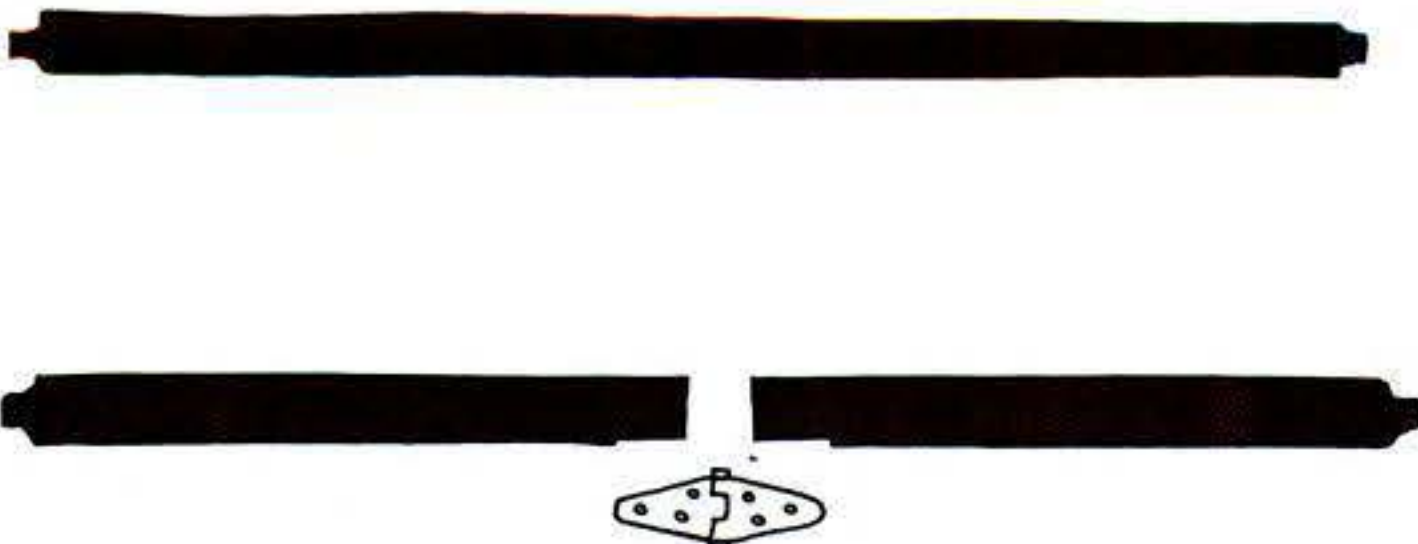
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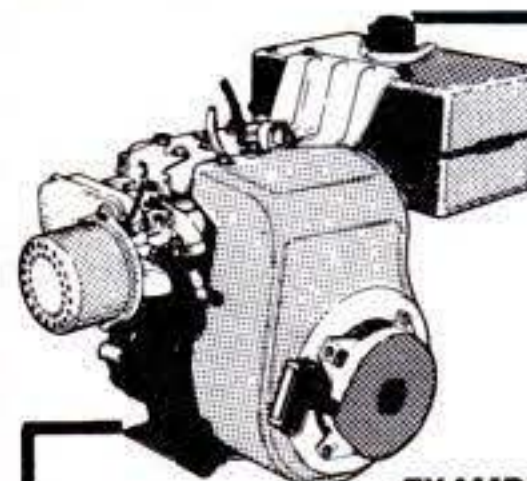
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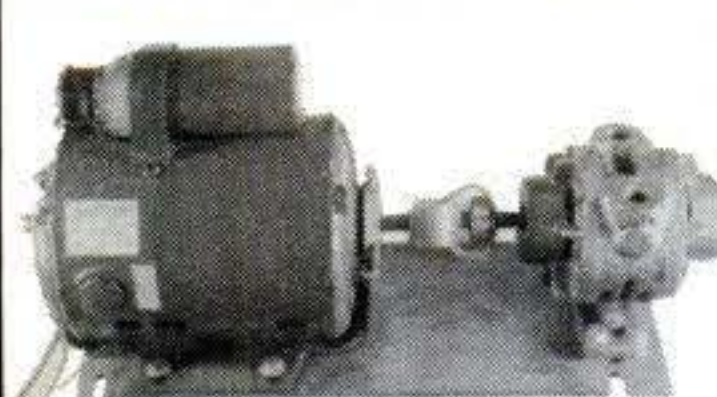
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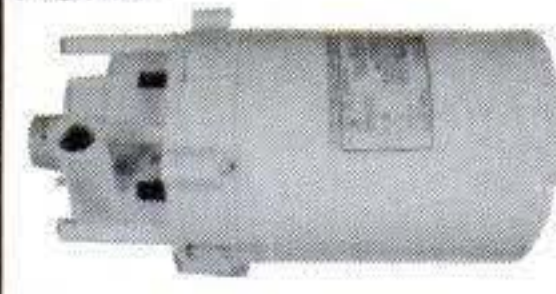
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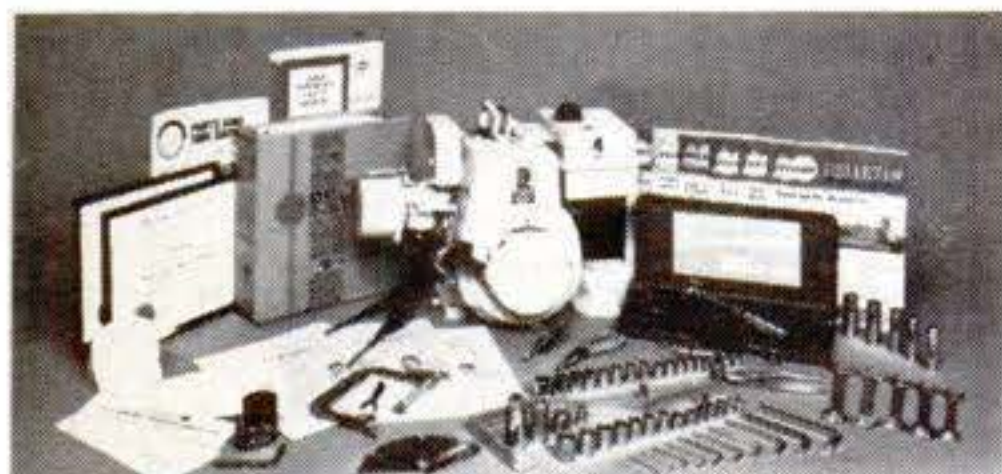
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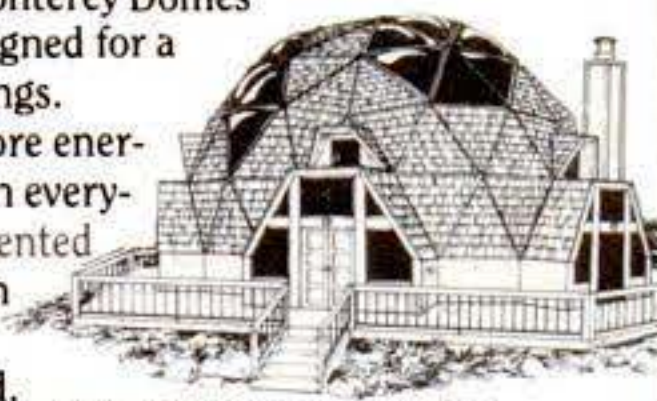
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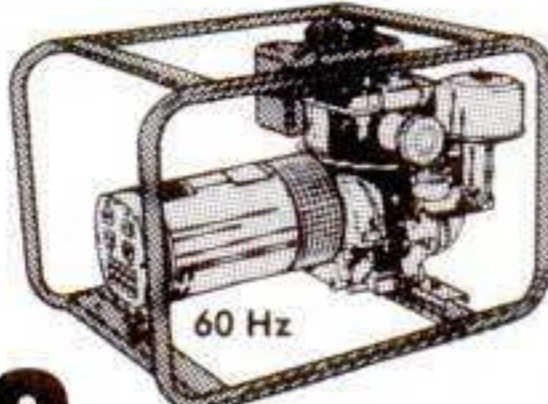
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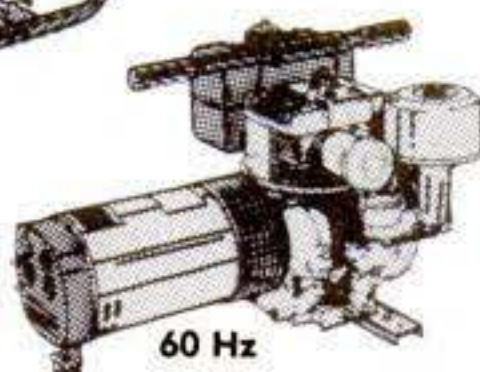
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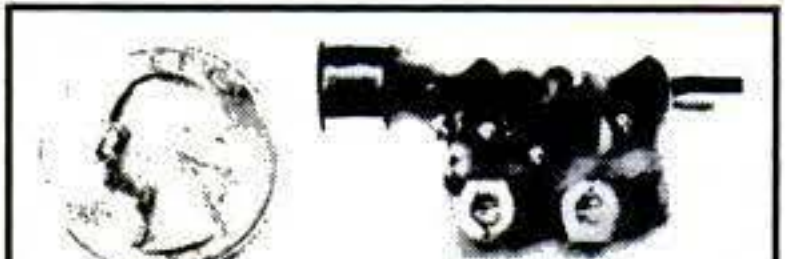
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607 Hotel Directory Days Inns of America provides a complete listing of over 400 hotels nationwide. Locations, maps, property descriptions, room rates, and program participation listings are included in the directory. Free

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612 Residential Locksets This full-color brochure from Kwikset describes the company's unique designs and architectural lockset styles for the home. Doorknobs, levers, entrance handle sets, and deadlocks are shown. 35¢

613 Garden Accessories A six-page full-color brochure gives detailed information on Lawn-Boy's 1987 line of self-propelled mowers, push mowers, and gas trimmers; a new blower attachment and thatch remover; as well as other lawn-and-garden accessories. Free

614 Navigation A four-page color brochure from Magnavox describes the Geonav electronic navigation device. For pleasure craft use, the Geonav uses digitized maps from the U.S. Coast Guard and provides an automatic method of plotting a course throughout most popular areas of the world. Free

615 Digital Video The full-color brochure from MultiVision Products describes the MultiVision 3.1, which turns any TV into a remote-controlled digital MTS stereo set. Two channels can be viewed simultaneously, multiple video sources can be swapped, and automatic scanning and action freezing are possible on a variable-size, movable picture. An audio amplifier drives stereo speakers directly. Free

616 Red Cedar Sidewalls The "Wallbanger Pocket Guide," from the Red Cedar Shingle & Handsplit Shake Bureau, contains step-by-step instructions for sidewall application of red-cedar shakes or shingles. This guide can save you 60 percent on labor alone. \$1

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618 Locksets A booklet entitled "The Burglar Doesn't Ring Twice," from Schlage Lock Co., provides tips on choosing and installing home locksets. Included is information on Schlage do-it-yourself home security systems and general anti-theft precautions. Free

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